An Astronomer's Life

by H.R. Butcher

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To my sons, Jeremy and Christo

Front cover: These domes house the ESO 3.6-m telescope and its spectrograph's auxiliary feed optics, respectively. I made extensive use of both for my research, as explained in chapter 9.

Image credit: ESO/J. Launois/Black Star.

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Preface

Do not forget the things your eyes have seen or let them slip from your heart as long as you live. Teach them to your children and your children's children.

– Deuteronomy 4:9

I was one of those geeky kids who from an early age knew he wanted to be a scientist. Not just any scientist, I wanted to be an astronomer. It was the only thing I ever seriously wanted to be. I did flirt briefly with the thought of becoming a medical doctor, like my father, but I didn't like the smell of his hospital or all the sick people there. Astronomy attracted me because I could spend long nights alone, looking at far away objects unlike anything here on Earth. Somehow, it was even good that you could only look, that you couldn't do laboratory experiments on the stars. They remain pristine and unsullied, and that increased the wonder.

In the end, I did become an astronomer, and have never regretted this choice of career. I have travelled the world, seen many wonderful things, and explored the unknown. But I do have one regret. I regret that when I was young, I was not much interested in my family background, in who my parents were and what their lives were like when growing up. I knew them as parents, of course, but not as people with friends and dreams and worries. As a boy, I regularly visited my grandparents, on both sides of the family, but again, I

never got to know them in any depth. I would like my children to know at least something about my life, what I am proud of, and why I did what I did. Not a person to talk about himself, I am certain my two sons, Jeremy and Christo, share the same lack of understanding of their father that I did of mine. So I decided I would write this short book.

I tell my story chronologically, dividing it into chapters that describe more or less self-contained periods of my life. There will certainly be episodes and events that are not included, that I have just forgotten about. And, I relate in some detail those achievements I am proud of, while passing over a good many less propitious matters. Again, partly this is because my memory is patchy, but partly it is because I have kept written records of the former and generally not of the latter. I suppose this is normal in autobiographies and memoirs. The reader may be assured, however, that I have failed at a good many activities, been rejected for a good many jobs, and, as an academic, had a good many negative peer reviews.

Some remarks on historical context are provided in most chapters, which point to events and trends taking place at the same time in the wider world. Except in the earliest chapters, the choice of these remarks reflects my memory of my concerns at the time, and at some level these must have influenced my life choices.

Finally, I declare, as authors of presumed nonfiction generally do, that any inaccuracies and misinterpretations in the book, which I hope are few, are my fault alone.

Canberra, March 2015

Chapter 1
Getting born

Lord, but he makes me wilt in his uniform.

– Marilyn Corning

Marilyn Corning and Harvey Butcher Jr. fell in love and married as World War II began to dominate life in the United States. It was late in 1942 when they first met. She had just begun a career as an operating room nurse at The Children's Hospital in Boston, Massachusetts. He was a young student at Harvard Medical School. She came from a middle-class New England family that traces its roots back to 1638 in Norfolk, England. He hailed from a farming community in rural Missouri, and was on an accelerated medical degree program sponsored by the US Navy – the war effort desperately needed doctors.

Their courtship was conventional. Harvey visited several evenings a week and they went out on dates at weekends. The courtship lasted much longer than Marilyn wanted. She expected he would formally ask her to marry him when they travelled west to meet Harvey's family in Missouri for Christmas in 1943, but he didn't.

Harvey wanted to wait until he finished his training. Upon graduation in June 1944, he accepted an internship in St. Louis and then finally did ask her to marry and follow him there.

It would mean a cultural wrench for Marilyn. The social norms of rural Missouri clashed with her more refined New England upbringing. But decide she did, and on 23 September in 1944, Harvey and Marilyn married in "The Old North Church" in Marblehead, Massachusetts, and then made the move to St. Louis.

Following his internship and first year of residency, Harvey was obligated to serve in the US Navy Medical Corps. Called up in April 1946, he was inducted as a lieutenant junior grade. His training as a Navy officer took place at the Naval Air Station, Inyokern, California. Then he was assigned a tour of duty in China, Manchuria and the Philippines as part of the American postwar program in the Pacific. Marilyn moved back to Marblehead to be with her parents and sisters.

Marilyn visited Harvey briefly at Inyokern in October 1946 before he shipped out. It is at this point that my own story has its beginning. Nine months later, on 3 August 1947, with Harvey still in the Far East, I put in my appearance at Salem Hospital in Salem, Massachusetts.

It is a custom in some English and American families to give their first-born son the same name as the father. This can continue for generations. It was in this way that I became Harvey Raymond Butcher III. My grandfather, Harvey Raymond Sr., didn't much like the name Harvey and called himself Ray. Why he and my grandmother decided to call their first-born, Harvey Raymond Jr., is lost from family memory. But they did. Harvey Jr. didn't mind being Harvey, which distinguished him from his father in day-to-day appellation. After I showed up, in the family Harvey Jr. became Big Harvey and for many years I was Little Harvey.

Marilyn wrote to her sister Priscilla on 8 January 1944. The letter was written on her return from her first visit to Missouri to meet Harvey's family. It gives a fascinating insight into what life was like in the Butcher family at the time, as well as into the cares and joys of a young woman in love awaiting a formal marriage proposal.

Dearest Priscilla,

Have just finished reading your last three letters to home, and only wish I could write such lovely ones. They are so detailed and interesting that as I said to Mother and Dad [Corning] it just seems as if you are right here telling us those things. Harvey and I are home for the weekend – gosh, but it was good to come home to Mother's bean supper – bet you'll be glad to have one too. Mother left all the Christmas decorations up so Harvey and I could enjoy them and not until I came home Wed. p.m. did I really feel the spirit of Christmas. There's no place like home I've decided.

Well, my dear, I must say right now I am so horribly excited about becoming an aunt. I can hardly believe it and nearly fainted when I called Mother as soon as I got back and she told me. Really, dear, this is more exciting than as if I had become engaged – which, of course, didn't happen. So happy for you that you are feeling so fine – don't think about having morning nausea and you won't feel nauseated. Now listen, Priscilla, just a word right here, for heavens sake watch those scales if you don't you'll put on an awful lot of pounds – quit eating sweets all together – not even a taste – Christmas and time to celebrate is over – honestly you must start right now – Harvey just told me to tell you you shouldn't go over 135 [pounds] and that's true – if you don't watch it you just wait and see – eat your fruits, vegetables, and milk mainly. Golly but I can't wait for you to come home but do want you to stay with Dick [Priscilla's husband] as long as possible. So glad you can come Pullman [sleeping car] – coach is no fun with someone and would be hell alone. Yes, dear, as soon as I finish this fourth pair of black socks for Harvey I shall start my needles a clicking for the little one. Little sweaters, booties maybe, bonnets – you never can tell. I'm so excited for you, but you watch your weight! ! ! !

Well, dear, I suppose you're terribly anxious to hear all about my trip. I'll start about from the time I last wrote. I bought a pretty new blue botany flannel dress-up dress, well liked by all and an adorable saucer hat. I wrote you about those, I remember now. Also told you about the luscious sweater I gave Harvey, knit his brother a black pair of socks, bought his Dad Alexander Woolcott's 'Long, Long Ago' which he loved, and his Mother a slip, and Grandmother Coty's bath powder – mailed all this too myself about two weeks before. I was all ready to go right down to the last button two days previous. Harvey came over every night that week for a few minutes and the day before presented me with my Christmas present – my ticket – then I knew for sure I was really going – made me promise to go to bed early, but was 'on-call' and off duty just ¾ of an hour in which I packed for some unknown reason – then was called and didn't get off till one – made me so mad because it was so unnecessary to have me on-call – but being so excited I could have stood anything.

Got my O.R. [Operating Room] neat as a pin Saturday a.m. Miss Jenkins let me off at 11:30 a.m. instead of 12:30, which was nice. Harvey was coming at 2:30 but as usual came ½ hour early. One of my anaesthetists gave me a lovely pair of fancy lace panties – looked like me she said – ha, ha. Anne gave me a kg jar of soft skin cream for my poor hands, which turned out to be just the wrong thing, so gave it to Mrs. Butcher. Betty Jo gave me a bar of Rogers&Gallet soap and best of all Helen Louise and Anna Devine packed an S.S. Pierce box of 'goodies' tied with a big red ribbon for us to eat on the train, to keep our backbones from touching our stomachs they said. The note was precious – you see, I'd been on a rigid diet and was down to 124 because I knew I'd gain – made Harvey promise to let me eat my share. I was so thrilled with it and it sure came in handy. Harvey implied I looked like Santa Clause when we started out.

I got everything in my big suitcase for him to carry, while I had a big book which I never looked at, my box of food, pocketbook, and knitting bag crammed full, washcloth, soap, knitting, hand cream, etc – all much needed. Your grey suit, Nat[sister Nathalie]'s jacket and tweed coat with brown accessories – really looked cute as Harvey said so himself. He came at two, me undressed, so had to hurry.

Finally got all downstairs and while he went for the cab I called Mother. Arrived at station and ate our supper, then waited from 3:20 plunk in front of gate for train at 4:50. While waiting, a class mate of Harvey's – Ed Doisy – and his wife came, going to St. Louis, which was just nifty. Service men allowed out first, so we got good seats all together. I was really on my way now you see, but I still couldn't believe it.

The trip to Albany was uneventful except that we lunched off the Doisy's who brought oodles of sandwiches. We changed at Albany and were fortunate enough to get seats, Harvey opposite the aisle from me – but the soldier beside him changed seats with me when Harvey asked him to, so his wife could sit beside him – thrill! Then I took my sleeping pill and dozed off. Had a pretty good night's sleep in his lap. Took my shoes off and in the a.m. couldn't get them on, my feet had swelled so – really looked as if I had pregnant legs – just a hint if you sit up all night. Awoke at 6:00 a.m., wide awake and nearly lost my mind until Harvey awoke about 9:30. The sun didn't come up till 8:45 just to add to my misery.

When all were finally awake we went to the diner for breakfast, which was fun. I now began to see our country – not a thing but cornfields for about 8 hours. I was amazed and as Harvey said, my education was just beginning. We played cards etc, Harvey reading every word in about three magazines. We were an hour late, so when it came nearly time for our arrival in St Louis, the other fellow on the train and the other three of us all got on the edge of their seats because I was to see the Mississippi River – what a disappointment – looked not much larger than the Merrimac – well we were in St. Louis.

We missed the train to Pleasant Hill, where folks were to meet us, by ½ hour, much to my glee because I was so tired, filthy, and runs in my stockings. Harvey called and got us rooms in a nifty hotel – taxied over and both cleaned up and changed clothes, then went down to our first good meal in 2 days and my first taste of western food – delicious turkey dinner – right then and there I wished horribly we were married, you know that

feeling of nostalgia. Well, we went back to my room. I washed my hair and we chatted and Harvey called home. Went to bed at 10:00, up at 7:00, taxied to station, bought box of chocolates for folks, then waited in front of gate without breakfast for 8:50 train out – got good seats for I ran ahead while Harvey toted bags.

Such nifty trains on those western lines, loads of people standing, uneventful ride except country was more rolling, beautiful suburbs to St. Louis – such little old decrepit towns as we got out. [Harvey's brother] Bill met us at Pleasant Hill – kissed me very brotherly. Harvey drove home really getting excited for the first time. Got to their home about 1:30 – such a dear little white house, real new looking and meticulous inside. Mrs. Butcher came running out and threw her arms around me and kissed me, saying 'and this is Marilyn' and kissed Harvey too. So you see I began to feel quite at ease.

She got our lunch, a nifty steak dinner, vegetables, potato and her canned fruits or something. I had a lovely room with double bed, dressing table, bureau etc. We sat around. Bill went and got Grandmother Swindell, who is just a dear – much ado about then over Harvey's knitted socks. They began to think I was something out of the ordinary. At 4:20 Mr. B. gets home, so I met him with a good hard handshake and a little conversation – found him rather distant and hard to get acquainted with, but I soon loved him too.

That evening we went over the family pictures for a couple of hours. Mrs. B. gave me a nifty one of Harvey – his college one, just wish you could see his baby pictures. He was a little dream, simply adorable. Finally went to bed.

From now on will just have to tell of things not chronologically for I don't recall the order too well – some things I do. We only had breakfast once while there, just fruit juice and coffee, for the two meals every day were real dinners to me. Mrs. B. said I had as much right to smoke as Harvey did, so I enjoyed one after each meal and occasionally snuck another in, when sort of alone then. When we went out I nearly went up in smoke, but got along surprisingly well.

Mrs. B. is a dear too, just full of life and questions – her only interests are right in her kitchen and her sons' affairs. She worked constantly, cooking 2/3rds of the time – hot rolls with every meal – pies, cakes, divinity fudge for the boys, all vegetables were those she had preserved – loads of lettuce and raw carrots and meat that I didn't know existed – had quail which is scrumptious, rabbit which is likewise, squirrel, pork tenderloin, steak, roast beef, turkey at Christmas, country sausage, ham, pork ribs, and can't remember what else. Every meal was delicious – wild honey, home made pickles, cranberry sauce, and heaven knows what else.

Mrs. Butcher is real tiny – 108 lbs. Rather auburn grey hair. Mr. B. is about Dad's height and just right in weight. He has been rather ill of late so just sits around, quietly reading and napping. His banking hours are 8:30 – 11:30 and 1:00 – 4:00, quite some life he leads. He fell in love with me, told Harvey it sure wouldn't take him long to make up his mind if he were in his shoes. He's often put his arms around me and call me little dear etc. I really won him over. Mrs. B. didn't say too much to me, but told Harvey how he musn't let me slip through his fingers and tried awfully

hard to make him see he should get married and not give up all happiness for the sake of his education. Said she would look forward to my coming back with him next Sept.

The thing that made me the happiest was when we were about to board the train in Adrian the day we left. Mrs. B. kissed me goodbye with tears running down her cheeks. Then Mr. B. shook hands with me, then they did the same to Harvey. When his Dad shook hands with him he said 'thank you, son, for bringing us the merriest Christmas we've ever had, Marilyn'. I nearly broke down.

Well, Tuesday p.m. we went to Butler to the cleaners – 10 miles away, then over to see Noreen. H. went in to get her – she is working nights so was just getting up and taking a bath. Harvey said she came out and just simply broke down – had not seen him in uniform. When she came out to the car she had obviously been crying, but didn't start again. We went out and got a coke at Maggie's, the town rendezvous. Of course, she ignored my presence in that she didn't direct one question to me, but I didn't care, just thought her rather rude that she didn't ask me how I liked the west or something. Poor Harvey felt like a heel but it was good for his ego. That Sunday we went down and met her latest, on for Christmas – a Californian and nifty fellow, but she's not going to marry him. I'll bet dollars to donuts she goes to St. Louis real soon to work, just waiting for Harvey to come in Sept. without me and then she'll begin to work on him again. We bowled that day, me about 40-70, her about 140-170 – she's tops in everything. One other evening we went down and took her bowling – visited in her home for a while and you can bet I got well eyed by her folks, but they were real pleasant.

One day we went hunting out on granddad's farm some 60 miles away – me toting a rifle which I couldn't even sight because I can't close my left eye alone. I nearly froze my feet too. Harvey and Bill got four rabbits and three squirrels between them. We walked what seemed miles thru cornfields and timberland. They were butchering a pig so saw that – a real farm it was, with a privy and stove in the living room with lanterns for light.

The highlight of our two weeks for me was our trip to Kansas City – 70 miles away. I took Harvey window-shopping for three hours. Needless to say he was miserable, but I had a wonderful time. It is a beautiful city with some nifty stores. You just ought to hear Harvey tell of it to appreciate it. I bought Mother a real pretty little hot plate thing. Harvey was ready to buy anything. About 6:30 we went to the Southern Mansions for dinner and the evening. Needless to say we were the first ones there – a night club at 6:30!! Such a nifty place and had a delicious plank steak dinner spread out with a few drinks over two hours – danced and then drove home in our first good snow storm. Ate our usual midnight meal and were off to bed. Every night we didn't go out, Harvey and I had the living room from ten on – the folks always adjourned at 10:00. Always had a fire too and always had our midnight snack. I weighed 123 when I left and 127 when I got back, so you see I really enjoyed myself.

Christmas day didn't seem so very much like Christmas, in fact I didn't see anything that made it look and me feel like Christmas until I got home – you can understand that. Grandmother [Swindell] was there, I

washed my hair, we had the tree the night before, dinner was wonderful much as the usual dinner, in the afternoon we rode out to a farm Mr. B. was invested in. In the evening we had a fire, then Harvey and I sat on the floor until Bill came in with his date, when we adjourned to the kitchen and completely finished the turkey plus a head of lettuce, cake, divinity etc. Always found that great sport.

Well, it soon came Friday and time to go. We left on the 11:50 train out of Adrian. How I hated to leave for I didn't know as I'd ever be able to go back. We had to change at Pleasant Hill for the St. Louis train, the Colorado Eagle, and as luck would have it we were without seats, I for the first time. Harvey gave our bags to the porter to put in the baggage car because he couldn't get place in the aisle with them. Unfortunately, we could have used them later, but couldn't get them – stood for three hours until they closed the diner and got seats there.

The Doisy's met us in St. Louis and took us home to a scrumptious roast beef dinner They have four boys all in college. Dr. Doisy teaches at St Louis University. A nifty family to spend New Year's Eve with for we were made to feel so at home. They have a beautiful home but no time to keep it, the type of kitchen that if you open the cupboard a thousand things fall out. Sat around the fire, all had nifty bourbon drinks. About 11:30 we began playing poker which lasted till 2:00 a.m. when we had a whole baked ham, cheeses, lettuce, coffee cakes, cookies, candy, all sorts of bread for our 'lunch'. Harvey got up early to go out to Barnes which nearly killed me for I did so want to see it, but got a bird's eye view as we drove to station in p.m.

Had dinner about one – quail (ten of them), fried chicken, peas, lima beans, turnip, potato, rolls, salad, hors d'oeuvres, plum pudding and fruit cake – ten at the table. Got the six o'clock train out and suffered miserably all the way home. I was so tired, nearly drove Harvey crazy, said such things as he didn't see why I couldn't shut up and sit still admiring him if I couldn't do anything else. Well, I was a wreck when we got back at 10:30, nearly dead the next day and to top it all I was on-call Monday night (got back Sunday night) and was up till 3:00 a.m. on a case. Slept Tuesday from 3:30 until 6:00 a.m. on Wednesday except for an hour for supper.

Christmas presents consisted of a lovely silver bracelet with turquoise stone from Harvey, powder and cologne from his folks plus some small stuff which is simply nifty, brown kid gloves from Nat, five (?) from Mother, soap from you know who, stockings from aunt Elsie, laundry bag from Roger (cute white one with little British emblem on it), and cigarette box full from Mildred. So much for that. I found yours simply wonderful on our trip – thanks again.

I'm well in the groove again, and fairly happy now that the ordeal of showing people the ring I didn't get is over. I can hardly read this myself.

It's Monday p.m. now as you can see by the change of pen. Hope you will be able to decipher this. It's what you asked for, isn't it?

Take care of yourself dear, and watch that weight! ! ! Can't wait to see you. My love and best to Dick.

Bet you're glad to see this [letter] at last.

Much love, Marilyn

Historical remarks

When Harvey and Marilyn courted in 1943, wartime industrial production was still ramping up. Rationing was in full force and restricted the availability of cars, bicycles, petrol and fuel oil, typewriters, shoes, meat, sugar, coffee, canned foods, and cooking fats. Generally, consumer goods containing metals and rubber were rationed, and community drives to collect scrape metal, used tires and used cooking fats (these last for the production of explosives) were a constant feature of life. Wartime cookbooks were published to provide adapted recipes.

The first-ever general income tax was introduced. By 1944 the average American paid over 20% of his or her income in tax, and the highest incomes paid at a rate of 94%. With consumer goods rationed, personal savings, often in the form of war bonds, reached high levels. Nationally, unemployment fell to one percent, average incomes rose dramatically, and price controls kept inflation low. The war saw the definitive end of the Great Depression of the 1930s. Civilian Americans on the whole enjoyed a constant or even improving quality of life during the war. Marriage came back into vogue and the birthrate began to soar.

From late 1943, the introduction of the P-51 Mustang fighter-bomber helped ensure that Allied forces would thenceforth maintain air superiority over Germany. A massive carpet-bombing campaign of German cities commenced. In June 1944, the Allies launched their invasion of occupied France. On Harvey and Marilyn's wedding day, 23 September, Operation Market Garden had just begun, aiming to forge a route through the Netherlands into the heartland of Germany. The Soviets were turning the tide on the eastern front, taking in succession Belorussia, western Ukraine, Romania, Bulgaria and Yugoslavia from the Germans. In the Pacific, American forces were working their way from island to island in a grinding and costly campaign. But the B-29 Superfortress bombers would begin operations in June 1944, with a massive bombing raid on Bangkok, Thailand. A month later they started carpet-bombing Japanese cities, a campaign that would only end a year later with the dropping of the first atomic bombs, on Hiroshima on 6 August and then on Nagasaki on 9 August, 1945. Germany surrendered unconditionally on 7 May 1945 and Japan followed suit four months later, on 2 September.

Harvey finished his medical training in March 1946, well after the cessation of hostilities. In April, he was commissioned as a Lieutenant junior grade in the US Navy. Late in the year, he began his tour of duty in the Far East, where he reported on the state of medical care, part of the American post-war effort to secure a lasting peace.

Chapter 2
First five years

One of the luckiest things that can happen to you in life is, I think, to have a happy childhood.

– Agatha Christie

The Corning family dwelling at 109 Atlantic Ave, Marblehead, was my home for most of my first year. It was a god-send for Mother to have the help and advice of family while Father was absent overseas.

Father was discharged from active duty in the spring of 1948. He was able to resume his residency training at Barnes Hospital, and Mother and I returned to St. Louis.

Our first home as a family was at 11 Faculty Lane, a pre-fabricated, temporary, war-time dwelling on the Washington University campus. I celebrated my first birthday shortly after our arrival. We lived in this house for almost two years. My brother Eugene was born while we lived there.

My earliest memories in life are three, all relating to our time at number 11. The first is of screeching tires and a screaming mother. I had wandered onto the street

in front of the house and almost been hit by a passing car. The second memory is of my mother struggling to hoist my stroller onto a trolley car going into the city. Trolley cars were not made for strollers, so she had to enlist the help of other passengers. And the third is of me sitting on the back porch, fishing with a small magnet on the end of a string for metallic fish at the bottom of a washtub. Curiously, of the three memories, the last is much the most vivid. I wonder what Freud would make of that?

As a young doctor-in-training, my father had to work very long hours, but his salary was enough that my mother did not have to work. Instead, she devoted herself to motherhood and child rearing. In later years, she would remark wistfully that she would have liked to continue her nursing career, but with two young boys and chronic, severe dermatitis on her hands, it was not a choice she felt she had.

The post-war period was one of economic growth and general optimism in the country. Among the legacies of the war were evolving social norms and an openness to new ideas. In 1946, just in time for use by the young Butcher family, Benjamin Spock published *The Common Sense Book of Baby and Child Care*. It counseled that many of the pre-war norms of child rearing had been too rigid, that each child is different, that parents should be both flexible and affectionate. The philosophy resonated with the times. For many years, at least in the USA, only the Bible outsold 'Spock'. My parents adopted its philosophy whole-heartedly and kept a copy of the book handy until well after I left home in my late teens. Happy and carefree, my early childhood surely owes a debt to Spock and the general softening of child rearing norms in the period.

A character trait in the male line of the Butcher clan is a prizing of the familiar, both as regards place

and routine. My father never felt comfortable outside Missouri and would spend the rest of his life in the St. Louis area, working at the Barnes Hospital where his career as a doctor had begun.

The only exception was a 9-month sojourn in Columbia, Missouri, starting in the summer of 1950. We moved there and set up house on a quiet street backing onto a rise, at the top of which was a cemetery. Brother Eugene and I were not allowed in the cemetery. We got our first dog in Columbia, a Dalmatian called 'Sparky'. From time to time Sparky would get loose, and head up to the cemetery. Then we could go after him and enjoy briefly what was forbidden.

My only other memory of our time in Columbia concerns a scar on my knee. One Sunday on our way out the door to church, I fell down our front steps and cut my knee. I probably should have had stitches, but common among physicians is a cavalier treatment of themselves and of family members. When my father gave us injections, for instance, he would routinely preface the puncture with, 'This won't hurt', and then would wiggle the needle vigorously to ensure it was actually in the intended blood vessel. He also had a strong preference for closing wounds with band-aids, disregarding the cosmetic results. I think this attitude came from his surgical procedure, whereby as head surgeon he would stitch up any inner wound with as coarse a pattern of suturing as possible, and leave the external suturing to his students. So it was that I got a band-aid on my knee, which healed to present an interesting scar that remained visible until sometime in my late 50s.

July 1951 found us back in St Louis, Father with a position as Senior Resident for a year, again at Barnes Hospital. We still qualified for a war-time dwelling on Faculty Lane, number 17 this time. It was a come-down from our house in Columbia but pleasant enough. At the bottom of the hill was a nursery school, which I was now

old enough to attend. (Nursery schools are called preschools these days.) Our next-door neighbors included Cathy Demorest, a young lady my age with whom I got on famously – she could climb the tree in our joint garden almost as well as I could. I say almost because at one point she did fall and hurt her leg, whereas I managed to avoid such embarrassment. At the bottom of Faculty Lane, across from the nursery school, lived Merlin Kilbury, a young man my age with whom I also struck up a friendship. Merlin was blessed with a massive port-wine birthmark across his face, a feature of perpetual fascination to my four-year old mind.

In the USA, a doctor's training ends with Residency. The next career step is to find a real job. As diligence, personality and luck would have it, Father managed to secure first an instructorship and then a fellowship in surgery with the Washington University School of Medicine – at Barnes Hospital, of course. But this also meant we no longer qualified for housing on Faculty Lane. A real, more permanent house had to be found.

Schools across the country at the time were, and for that matter to a great extent still are, run locally. The result is a very wide range in quality. For my parents, buying a new house meant first finding a suburb having good schools. They were fortunate to find an affordable house for sale in the town of Webster Groves, an outlying suburb of St Louis having a reputation for a quality school system. They paid about $15,000 for a four-bedroom dwelling with a large back garden. (The house, admittedly renovated and with an extension, recently sold for $455,000) To top it off, it was easy walking distance from the local elementary school. I was to spend the next twelve years, my formative years intellectually, living in this house at 944 Providence Ave.

Historical remarks

By 1947, the USA had largely transitioned to a civilian economy. Most factories had been converted to civilian manufacture. The savings accrued during the war in the form of US war bonds were paying out, injecting a massive flow of capital through the economy.

The almost ten percent of the US population that had been in uniform could, and did, make use of the G.I. Bill, which provided for low interest mortgages and loans to start businesses, and support for training and education including tuition and living expenses for attending university. The G.I. Bill is largely credited with creating the strong, well educated, middle class in the country that was to be so extraordinarily productive economically in the coming decades. Together, these measures led to the country entering a long period of great prosperity.

In contrast, the international scene was in turmoil. The Soviet Union consolidated its control over eastern Europe, and began supporting communist guerilla movements across the world. The North Atlantic Treaty Organization was founded to counter further Soviet expansion into Europe. A US policy of containment was introduced, whereby countries on the periphery of the Soviet sphere of influence were supported militarily. In Asia, the communists gained control of mainland China. The Soviets controlled North Korea, and in 1949 together with the communist Chinese army, invaded South Korea, setting off the Korean War. Colonialism was being dismantled rapidly. India became independent of the UK in 1947, and Indonesia from the Netherlands in 1948. The British withdrew from Palestine, the Jews proclaimed the State of Israel, and neighboring Arabic states immediately attacked.

In 1949, the Soviets successfully exploded their first atomic bomb. The US tested the hydrogen bomb in 1952, and the Soviets followed in 1953. Fear of communist expansion and even of another World War moved American politics to the right and led to a renewal of spending on the military. From 1948 to 1952, the defense budget grew by a factor of almost 40, and consumed over half the Federal budget until the 1970s.

On the other hand, the acknowledged role of science in winning the War led to both private and government investment in research. The 1947-1952 period saw discovery and innovation surge. The theory of quantum electrodynamics in physics represented a major step forward in understanding the physical world. The Big Bang origin of the cosmos was proposed and the 200-inch telescope, the largest in the world until the 1980s, went into operation. Techniques to discover and manufacture antibiotics allowed a broad spectrum of new medicines to be produced. The transistor was invented, as were the Tupperware seal, the Frisbee, and Velcro. The credit card, the video tape recorder, the bar code, and diet soft drinks put in their first appearances. By any standards, it was an exciting period.

Chapter 3
Growing up in Webster Groves

Webster Groves: It is the best of America.

– Charles Kuralt, narrator of *16 in Webster Groves*

…a superficially friendly, prosperous, progressive, religious, charitable, arts-and-education oriented bedroom community… [but] in fact clique-ridden, status-oriented, hyper-competitive, hypocritical, prejudiced, and materialistic.

– Charles Nathaniel, on *16 in Webster Groves*

November 1966. The CBS television network broadcast *16 in Webster Groves*, an hour-long documentary on growing up in Webster Groves, Missouri. The town was painted as 'six square miles of the American dream' but also as profoundly snobbish and insular. The show caused so much anger and embarrassment in the town itself that CBS was moved a year later to broadcast *Webster Groves Revisited* on the effect the documentary had on the town. The show made it into the national consciousness, inspiring the television series *Lucas Tanner* that ran in the 1974-1975 season. President Bill

Clinton visited in 1996 to single out Webster Groves High School as a 'typical' school combating drugs and violence with some success. *Time* magazine featured it in 1999 in a cover story on '*A week in the life of a High School*'. *Family Circle* magazine in 2008 listed Webster as among the top ten best towns in the country for families.

I grew up in Webster Groves, and I can vouch for the essential veracity of the portrayal of the town given in the original documentary. Outwardly, it was a most pleasant town of relatively well-off middle class families. At least in the part of town where we lived, it was safe. There were some 35 churches, almost one on every street corner, and the town was 'dry' (alcohol could not be purchased in Webster). This was felt to be proof that family values prevailed, even though the bars and strip joints in surrounding towns were full in the early evening as commuters returned home from their jobs in St. Louis. Although the schools were integrated formally in 1956, segregation in housing was a fact and all through elementary school I had no black children in my school. Outside school, a social hierarchy was constantly and everywhere in evidence. But civil rights protests, so prominent in the news of the day, were not on the agenda in Webster Groves. On the national scene, Senator Joe McCarthy was ruining the lives of many prominent Americans, with the silent support of most Webster inhabitants.

None of this affected me much as a child, and I recall feeling safe and happy for pretty much all of my childhood there. In hindsight, it was a privilege to grow up in Webster Groves. Later, I would choose societies with similar characteristics – staid, moderately progressive, socially homogeneous.

My parents were consistently clear that their choice to move to Webster had had to do with the school system. I was five years old when we moved and could

start kindergarten right away. Lockwood Elementary, a public school located 100 meters from our house, through a small wooded area, was the obvious choice.

Both parents believed a public school would expose their children to a cross-section of society. They felt that learning to deal with all kinds of people is an important socializing function of early education. Our neighborhood, however, was overwhelmingly middle-class and white, of Anglo-Saxon or German ancestry. The main social extremes were a few families who were Catholic, and mostly they sent their children to parochial (church sponsored) schools. The irony of the view, that we would experience a cross-section of society when we lived in such a socially homogeneous part of town, would strike me only many years later, when I had to think about schools for my own offspring.

Elementary school in the 1950s started with kindergarten and continued through age 11 and the 6th grade. My time at Lockwood Elementary was relatively carefree and left me with only a few strong memories.

I recall in the first grade anticipating with excitement that we were going to learn to read and write. But the first word we were tasked with writing was 'ill' – one short stripe and two long ones. I had never heard of the word before and had no idea what it meant. I proceeded to panic. Were we to work with a whole language I didn't know? What had been eagerly awaited became fraught with anxiety. It took some weeks to regain my initial enthusiasm.

Every morning from first grade on, we dutifully pledged our allegiance to the Stars and Stripes. Prayer was forbidden in public schools by the country's constitution. I suppose this ritual took its place. We learned that the United States was the best country in the world and were taught the myths of the nation. We learned, for example, that George Washington was father of the country, and as a young boy had chopped down his fa-

ther's prized cherry tree. When confronted he replied, "I cannot tell a lie, Father, it was I." His father was so proud of this honesty that George was praised and escaped punishment. At Lockwood Elementary, a schoolmate owned up to breaking a window, and he too was first praised for his honesty, just like George. But then he duly got punished. It was a salutary lesson in the real world that I have never forgotten.

At lunchtime we had the options of going home to eat, bringing a box lunch, or buying lunch in the school's basement cafeteria. A national school lunch program was in effect and one could buy a hot lunch of meat, potatoes, veg and dessert for 25 cents. A half pint of milk to drink was 2 cents if bought separately. In the early grades I generally went home. Later on I looked at the menu ahead of time and decided whether to bring or buy. I looked forward to food fights but these only occurred very occasionally, and I never had the courage to start one. Dares were common, however, and might include daring a friend to eat dead houseflies mixed in his mashed potatoes, or tomato ketchup stirred through chocolate pudding. Lunch break was 45 minutes and those who finished early would head outside to the school playground. There was no supervision and some years bullying was a problem. I only got beat up once, in the 4th grade, and not severely enough to have to tell my parents. Generally, I was quite shy and did not participate enthusiastically in playground games. During most of grade school I had a pronounced stutter, which didn't help my joining in.

Teachers sometimes had difficulty maintaining order. One elderly teacher had the simple but effective approach of turning off her hearing aid when the noise got too loud. Occasionally an altercation would culminate most delightfully. One day in third grade, Miss Jane Cooley, a particularly spirited young lady, felt incorrectly accused of some infraction. Jane got angry,

picked up her chair and threw it half way across the room at the teacher. I was impressed. They were solid little chairs and I am not certain I could have thrown one that far. Luckily her aim was poor and the teacher escaped harm. Jane got sent to the Principal's office, of course, and was suspended from school for several days. But she earned my respect.

In the upper grades, it was a sought-after honor to be appointed to raise the flag in front of the school in the morning, and lower it at the end of the school day. There was a rigorous, almost military-like protocol for folding and unfolding the thing, including never letting it touch the ground. Should it start raining, one was expected to hasten outside to lower the flag to keep it dry. One could also volunteer to man the cross-walk on a busy nearby road, for which you got to wear a special reflective shoulder belt and hold other pupils back until it was safe to cross. When I got the chance to do this, I was told to be sure to note down the registration numbers of cars that didn't stop when they came to the cross-walk. But after the first day, my list was so long it was obvious that 'stop' meant something different to adults than it did to me. I stopped worrying about drivers' behaviors. In any case, there were no accidents during any of my turns at cross-walk duty.

All during elementary school, the government ran health programs. We got free smallpox shots and polio vaccinations. Our hearing and eyesight were tested regularly. It was early in the 5th grade that I was found to be nearsighted and would have to wear glasses. Glasses branded me as what today would be termed a 'geek', but that suited me fine, because that was in fact what I was and I didn't feel bad about it.

At home, it was teeth that were on the agenda. Brushing our teeth was as important a part of the bedtime ritual as kneeling and saying our prayers. This was before general fluoridation of the town water supply and

Mother insisted we take fluoride pills each morning at breakfast. My baby front teeth refused to fall out and had to be pulled to give my adult teeth room to grow. I sucked my thumb all through kindergarten and well into first grade, until peer pressure put a stop to the practice. The result was that my baby front teeth protruded and made it a stretch to bring my lips together. As my adult front teeth put in a belated appearance, they also preferred a forward orientation. This was unacceptable to Mother, so as soon as both front teeth were fully grown in, I had to get braces fitted. They hurt, I can tell you, and I dreaded the monthly visits to the orthodontist to have them tightened. Things improved a bit in the 6th grade, when a gentler pressure was applied through the use of small rubber bands between the lower back teeth and the upper front ones. The best thing about the rubber bands was that I wasn't the only pupil with them. We privileged possessors of orthodontic rubber bands could, and did, shoot them at each other across the classroom, an all the more delicious activity because the teacher was mostly unaware of what was happening.

Summer vacations were long and hot. Long, because they lasted fully the three months of June, July and August. Hot, both because Missouri has a continental climate, cold in winter and hot in summer, and especially because in the early years we did not have air conditioning at home. I recall lying naked at night for hours bathed in sweat on a wet mattress. Many days we were obliged to take salt tablets to compensate for the loss of body salt by perspiration. When we finally did get air conditioning, we would stand or sit in front of the cool air stream for long periods. How could we ever have lived without it?

A full three months of freedom meant we children had lots of free time, even after visiting grandparents or vacationing somewhere as a family. I could follow my interests, hang out with other children in the neighbor-

hood, and until my parents were shamed into acquiring a television set of our own, spend hours at a neighbor's house watching cartoons and children's shows. Some summers I attended playschool or summer school several days a week.

Every other year we drove east to Marblehead for several weeks to visit Mother's family. The grueling 2000 km trip took three long days on mostly two-lane roads in an auto without air conditioning. Our average speed could not have much exceeded 60 km per hour.

One particular episode during these trips is deeply engraved in my memory. Father drove most of the time and did not want to stop except as pre-planned for gasoline or for the night's motel. He sometimes got seriously grouchy if we children wanted to stop to go to the toilet. One day I found myself in dire straights and absolutely had to pee. I was in the right-hand front seat and brother Eugene was in the back seat directly behind me. Mother rummaged under her seat and duly produced a glass jar for me. I proceeded to do the deed, no easy feat on a bumpy, twisting road. When the jar was full, I was instructed to empty it out my window, which I did. Unfortunately, I did not check that Eugene's window behind might also be open. He got the contents full in the face, he did. He was not amused. While to this day I maintain no malice was intended, it would be a sore point between us for many years.

Once in Marblehead, we could look forward to a warm welcome from Grammy Corning. She was always so very glad to see Mother, and whenever possible she would organize to have her three daughters – Priscilla, Marilyn, and Nathalie – and their spouses over for a visit. During our stays, they would usually also invite us to their homes for barbecues and to play with our cousins.

Grandpa Corning on the other hand was keen on regaling us endlessly and repeatedly with stories of crime and criminals and of the doings of the wealthy in

the area. I was more interested in him telling about his time as a flying boat pilot and instructor during the First World War, but he never seemed to want to talk about his own life very much. He did have a workshop in the basement of their house now at 18 Tufts Street. I was not allowed to touch anything there, but he did make toys for us, including a lovely model sailboat that I took back to St. Louis. For many years I sailed it on the lakes of Forest Park in the city.

The highlights of each of these visits, however, were when Uncle Freddy (Nathalie's husband) took us out sailing. He was a consummate small boat sailor and had no difficulty navigating through crowded Marblehead harbor under sail. He would take Father, Eugene, our cousins and me lobstering and fishing, sometimes to spend nights moored off small islands, enjoying an evening meal of freshly caught beasties and sleeping in hammocks outside on his boat. I found these excursions exciting, to the point that I still feel an affinity to sailing and to the New England mystique of sail. Perhaps had I chosen a commercial career I would have enjoyed moving to Marblehead and taking up sailing in a big way.

Alternate summers we would visit our grandparents Butcher in Adrian, Missouri. Sometimes we drove and sometimes we took the St. Louis to Kansas City train, disembarking and meeting grandparents at nearby Pleasant Hill. My memories of Adrian are several.

Grandfather 'Ray' Butcher owned and operated the only bank in Adrian. It was not a franchised bank but his own commercial undertaking. It had a single room with a large, free-standing safe that held the money. Of particular interest to young visitors was a bracket, out of sight under the single teller's window, for a sawed-off shotgun pointed at the customer! The shotgun itself was not in place during my visits, but Grandfather had started the bank in 1933, at the height of the depression-era outlaw period. Gangsters such as John Dil-

linger, Bonnie (Parker) and Clyde (Barrow), Pretty Boy Floyd, and the Ma Barker gang regularly robbed banks across the mid-west. Evidently, the shotgun in the Adrian bank was thought to be a necessary and appropriate measure. To the inevitable question I was told it had never been used in anger.

Adrian being a rural town, the main meal of the day was at noon. Grandfather walked home from his bank at noon, and after dinner took a 45-minute nap on the living room sofa, before returning to work. Grandmother spent her day in the kitchen or attending to household chores.

Even though Grandfather was a banker, the rhythm of life during my earliest visits was that of a farm. If chicken was on the menu, a neck would have to be wrung and the feathers plucked by hand. It is true, I have seen it myself, chickens actually do run around crazily for a short while after their necks are wrung. If fish was to be had, Grandfather took us fishing. Refrigeration was ice, which was delivered periodically to the house in big blocks and stored in an 'ice box' in the kitchen. There was a bin in the cellar for keeping potatoes over winter, where they grew hugely long sprouts. An old stove there was used to make lye soap with lard from the kitchen and ashes from the open hearth in the living room. It was ferocious soap that took some of your skin off if you were not careful. There was a drop-toilet outhouse behind the main house. It had two seats and smelled awful. In the summer it was full of wasps and spiders and was scary as hell, especially at night. There was a hand pump for water in the kitchen, but by the time I began to visit also a tap for running water. The telephone had a hand crank that you turned to let an operator somewhere know that you wanted to make a call. You often had to wait to talk to the operator because the phone line was common to 5 or 6 homes in the area and frequently was in use. But while waiting you

could, of course, should you be so inclined, enjoy listening to the other conversation, sometimes even joining in.

Passenger trains did not often stop at the Adrian station. But each day they did collect the mail. The postmaster would put the mail in a canvas sack and hang it on a pole outside the station. The 1 p.m. train to Kansas City would roar through at high speed, with a hook sticking out of the mail car that would snatch the outgoing Adrian mail. It was a joy to watch.

Young boys with lots of time on their hands will get into mischief. We got scolded regularly in Adrian, if not much punished. However, when we uttered a forbidden word ('shut-up' was one such), or verbally disrespected our elders in any way, the punishment was swift and always the same. Grandma would grab the offending grandson by an ear, yank him into a head-lock, and proceed to wash his mouth out with soap. The symbolism of washing away the offending sounds was lost on me until many years later. At least it wasn't the lye soap she made in the cellar.

Santa Claus died in Adrian. I must have been ready for his passing, as it was not as traumatic as one might have expected. One year Eugene and I brought our Christmas stockings to Grandma's and hung them from the mantle above the open hearth in the living room. We duly let the fire burn down before bedtime and had *The Night Before Christmas* read to us. We were told that Santa would also come to Adrian and climb down the chimney to fill our stockings with goodies, but only after everyone was in bed and asleep. We put out cookies and milk as a snack for him, then Eugene and I went excitedly and without complaining to our beds upstairs. Parents and Grandparents retired to the kitchen to wash up the supper dishes. As soon as I heard them there, I snuck out of bed – it couldn't have been 10 minutes after saying our prayers – and went to sit on the stairs and wait for Santa. But lo! The stockings were

already filled and it couldn't have been by Santa Claus. Wiser, slightly disappointed, but perhaps also a little thrilled to be in possession of such important information, I returned to bed. When confronting Father in the morning, he made it clear I mustn't tell Eugene.

At home at 944 Providence, work and school governed a routine that hardly varied. Eugene and I would rise at about 7:45 a.m., to be at school by 08:30. Some days we came home for lunch, but we were always home from school just after 3:30 p.m., with free time until dinner.

Father and Mother rose at 6 a.m. Mother put breakfast on the kitchen table at 6:15 sharp – eggs, bacon and coffee without variation. It was a period in Father's career when he performed surgery every morning and he frequently remarked, "The knife comes down at seven!" He would finish at noon, do ward rounds for current patients with his students in the early afternoon, and then any research or writing. He would be home again just after 5 p.m. His hobby was archery and he would frequently shoot in the backyard or basement until dinner. After dinner he would often read or write until bedtime. He went to bed at 10 p.m. Even when we had guests for dinner, he would stand up at 10 p.m. and announce that people should leave now because it was bedtime.

Mother maintained her New England custom of almost always preparing a sit-down dinner in the dining room, with a proper tablecloth, cloth serviettes, candles in winter, and silver dinnerware that had to be polished once a month. I hated carrots and broccoli, but ate most everything else, although it must be said our diet was not particularly adventuresome.

If the food may have been unexciting, another aspect of dinner could be quite gruesome. Mother had been a theater nurse and was interested in Father's surgical activities, which would frequently form an important

part of the dinner conversation. A story firmly lodged in memory is of a slip of the scalpel that punctured an aorta. Blood spurted not only over Father and his assistants, but also all over the bright light above the table. In the relative darkness, no one could see to stop the spray or start to repair the mishap. Panic ensued and Father admitted it was touch and go for a while. Evidently the patient survived, but I wonder if he or she was ever made aware of how close a call it was.

I had casual friends in the neighborhood who also attended Lockwood elementary school, but no close ones. I was perfectly happy puttering around alone or with Eugene, playing in the side yard, watching television or reading. As far as I remember, we never had any homework to do while in elementary school, certainly not until the 6th grade.

Most people do not decide on a career until well after they leave school. But I recall with absolute clarity the day in the 5th grade that set the subsequent course of my life.

Science and arithmetic were subjects I particularly enjoyed. We were doing a unit on the Solar System. I learned that all the planets go around the Sun in a plane, also that each is spinning – the spin of the Earth giving us our day-night cycle – and that all the spins are in the same direction as the orbits about the Sun. Only Uranus did not follow this rule. While it pretty much orbits the Sun in the same plane as the other planets, its spin is at right angles to its orbit and to the spins of all the other planets. Wow! Something had happened to Uranus in the early Solar System. What could it have been? I wanted to know. I decided then and there that I wanted to be an astronomer and figure out what happened in the Universe a long time ago. I would never waiver from this decision.

At the end of that same school year, on 2 June 1958, sister Nadine was born. Grandma Butcher came

to look after Eugene and me while Mother was in hospital. In the weeks that followed, we were fascinated by our new family member. But then Mother returned to hospital in a first hint that something was not right. Postpartum depression is perhaps not uncommon, but her depression was unusually serious and would last, episodes coming and going, for the rest of her life. Symptoms may have been manifest earlier, but they only became evident to me that summer. Ultimately, they would change my relationship with her. They would take a particularly heavy toll on Father as well.

My 6th and final grade at elementary school began in the autumn of 1958. Early in the year, all Lockwood Elementary 6th graders got to spend three days at Camp Wyman near Eureka, Missouri. The purpose was to ensure that we city children would have a chance first hand to learn about and experience nature. My recollections of the camp are three.

We found fossils of sea creatures in the limestone rocks nearby, a convincing demonstration that Missouri used to be at the bottom of the ocean. This was amazing.

I liked walnuts and tried those still hanging on the trees. They were not yet ripe and tasted excruciatingly awful. I ran to the showers and ate some soap to remove the taste. I had had extensive experience with soap in my mouth, as noted above, and had no trouble deciding it was the lesser of the two bad tastes.

Finally, and far and away most importantly, we looked through a telescope at the Moon, at Venus and at Saturn. It was a little 6-inch Newtonian reflector in a wooden tube, set out in the field with the eyepiece at just the right height for a small boy. I was gobsmacked! You could actually see the mountains on the Moon, the rings of Saturn, the crescent shape of Venus. With your own eye! Just like in the books! This was before the Hubble and other space telescopes, and such a small instrument gave almost as good images as were otherwise

available in books. The owner of the instrument was Mr. Stuart O'Byrne, a well-known amateur astronomer who lived in Webster Groves. He explained that the wooden tube didn't mean he was poor and couldn't afford a proper metal one, but that the wood produced less disturbance of the air inside the tube and therefore gave better images. Mr. O'Byrne would become an important mentor in future years.

Well, I clearly had to have my own telescope. I received it as a present that Christmas. A 3-inch Newtonian reflector, it kept me busy evenings for much of the rest of the school year. On clear evenings, I would explore the sky from our back garden. When it was cloudy I would pour over *Norton's Star Atlas* and read books about observing with small telescopes.

Two final memories from this phase of life bear recording. My mother was fairly religious and every Sunday she attended the local United Methodist Church in Webster. Father generally stayed home and did chores, although he would attend on the main religious holidays. He told us children he believed in God but was not enamored of His worship in churches. As soon as Eugene and I were old enough, we were taken along to Sunday school, which took place at the same time as Mother attended her church service.

Sunday school was pretty much like regular school, except it was about God, the Bible and worship. Its main goal was to teach us enough about the practices of Methodism to be allowed officially to join the Church – that is, to become 'confirmed' before the congregation as a true believer. I do not recall whether I ever actually did get confirmed. If I did, it was because I accepted the lessons without much question, kind of like accepting that one eats eggs or cereal for breakfast. If I did not, it was because of one particular lesson.

Generally our religious teachers were indistinguishable from each other. The Sunday in question,

however, featured a Colonel in the US Air Force. That immediately pricked this small boy's interest, because the sixth Commandment says, "Thou shalt not kill", while this fellow sort of did that for a living. It turned out to be a fascinating lesson. The Colonel was completely honest about his beliefs. He didn't know whether there is a God, or whether the Bible is His word. He didn't think the Christian Church has all the answers and noted that it had done bad things in the past. He said he considered himself 'agnostic' and he explained what that meant to him. It was a revelation to hear someone saying such things. It made an indelible impression. Clearly he felt he had every right to do so, although I don't suppose he got invited back.

I think that Sunday probably marks the moment when I started thinking critically about life and whether I believed all the things I was being told. A concrete framework for critical thinking came the following summer. I attended a local summer school and learned about the 'scientific method', in which one makes 'hypotheses' – a big word that clearly meant the lesson was important – and then performs tests to disprove them. That is, you can never know for sure that something is true, but only that it has not been proved false. Furthermore, the tests have to be of a nature that anyone can do them independently and reproduce earlier results. This was so sensible that I immediately decided there could not be any other appropriate approach to understanding the world.

As I graduated from elementary school, therefore, I was ready to absorb new material critically, to search for broader context and to seek perspectives outside the limits of the school curriculum. I looked forward to starting high school.

Historical remarks

The decade of the 1950s in the USA featured rapid improvement to people's living conditions, accompanied by a fear of Communism. Several developments affected my life in concrete ways.

Commercial television grew exponentially in availability and popularity in the early 1950s. By 1955, half of all US households had a television. These were almost exclusively black-and-white and it would take another decade for color television to become common. Air conditioning also became widespread. By the 1950s air conditioning was available in many cinemas, shopping centers, railway cars and offices. But even in 1965, home air conditioning was still only present in 10% of homes.

The race with the Soviet Union to develop nuclear weapons fueled American angst that the USA might be attacked. President Eisenhower proposed an interstate highway system similar to the German autobahns, whose purpose was both to promote the rapid transport of troops and materiel across the country, should the US be attacked, but also to improve the efficiency of interstate commerce generally. Construction was authorized in 1956, although it would take over 30 years for the system to be completed. It is hard to imagine today how slow and tiring interstate road travel was during my childhood.

Air raid sirens were installed across the country in the mid-1950s, and I recall as a child listening attentively to the monthly siren tests, feeling reassured the system was still working properly. Some people built bomb shelters, and more kept supplies of canned food and water in their cellars. Toward the end of elementary school, our regular fire drills at school were supplemented with bomb drills, in which we practiced hiding under desks or sheltering in hallways.

The Soviet atomic bomb was found to have been designed using information gained by spies in the USA and UK. The subsequent fear of spies in our midst was fanned by right wing, populist politicians, Senator Joe McCarthy being the best known. The tactics of fear-mongering were not dissimilar to those used today by the Republican Party: inflammatory, unsubstantiated claims and downright untruths that play to ignorance and fear. In the 1950s, most public institutions instituted a 'loyalty oath' requirement – even my *elementary* school did so. The role of the FBI in providing selective information to the media to discredit targeted individuals was crucial to the witch-hunt led by Sen. McCarthy for leftist sympathizers. This activity by government agencies is a salient lesson today, namely that the surveillance programs undertaken today by the Dept. of Homeland Security and the NSA can become a serious danger to society.

Chapter 4
Expanding horizons

A mind that is stretched by a new experience can never go back to its old dimensions.

– Oliver Wendell Holmes Jr.

The next six years were an exciting and mind-expanding time. New ideas and experiences challenged my views of the world. I knew I would have to leave Webster Groves to become an astronomer, so the rest of the world became a subject of intense interest. This chapter highlights some memories of this exceptionally stimulating period of my life.

Junior High School

It is well known that the rapid physical and emotional development of children at ages 12 to 15 makes for unstable and sometimes disruptive behavior. Elementary schools and high schools would rather have little to do with pupils at this age. In the mid-1950s the Webster Groves School District decided to put grades 7 to 9 in separate schools – so-called Junior High Schools. These days Junior Highs have been replaced by Middle Schools, which are a tweak on the concept.

When I reached grade 7, there was only one Junior High School in town. At Hixon Junior High, the world took two forms. There was the playground before school and during lunch recess. Here there was no adult supervision and it was survival of the fittest, or in my case of the resolutely inconspicuous. An early incident determined my attitude to the playground.

One lunchtime I came on a smallish boy lying on the ground in the fetal position. He was being pummeled by a much larger fellow, to the enjoyment and with the enthusiastic encouragement of a gathering crowd. Suddenly a young lady stepped forward and cried out, "Leave my boyfriend alone!" She was of course ignored. She paused a moment, then grabbed the attacking fellow by his hair, yanked him off her boyfriend, and planted her fist with a mighty blow squarely in the offender's face. Blood gushed from his nose as she pushed him aside and bent down to console the love of her life. From then on, I spent as little time as possible on the Hixon playground.

The other world was the classroom, and here things were better. We had a different teacher for each subject now, and some knew their subjects well. We could even choose a foreign language among the three offered: French, Latin, or Spanish. In hindsight, Spanish would have been most useful. At the time, however, I imagined that the language would be spoken mainly by poor people, and I didn't see myself needing to speak to them much. Latin would perhaps have been helpful in later life, but at the time I could only see it as a dead language that was very likely to stay dead. French on the other hand was the language of diplomacy, of love and of fine cuisine. Whether I would ever need to speak it in anger was beside the point. French seemed the only sensible choice.

Math was a disappointment. It was a review of the arithmetic we had studied in elementary school. Ev-

identently, the student body derived from a diversity of backgrounds and the review was needed to align knowledge of the subject. But if math was a bust, science class proved nothing short of wonderful.

It was the teacher who made it so. His name has faded from memory, but what he did has not. The curriculum covered a broad spectrum of science, from biology to chemistry and physics, all in the one year. It was interesting with lots of new ideas and facts, and he taught it well. But the real source of the wonder lay in the extra-curricular lessons he provided, together with his unusual approach to all manner of things.

For example, on many days we would have a test or a reading assignment to do in class. As we would begin to work quietly, teacher would pull out a dead cat. It was not just any old dead cat, but one that had been carefully embalmed, with its veins made blue, arteries red, and nerves gray. If you finished your test or assignment early, you could join him, see what he was dissecting on the day, and ask questions. For us geeks, this was truly wonderful and intensified our curiosity and wonder.

Chemistry to twelve-year old boys means explosives and rocket fuels. In schools these days, teaching-rockets are plastic bottles partially filled with water and pumped up with air. When the pressure is released, they shoot a short distance spraying the water out behind them: For every action there is an equal and opposite reaction and so on. At Hixon, the lesson began with combustion. What makes something burn slowly like a candle, or quickly like gunpowder? A practical demonstration of how to make and detonate your own gunpowder was a classroom exercise and quite entertaining. But it was the rocket fuel that beat all. We learned that you have to get the combustion rate just right, or the rocket will either fizz or blow up. For iron pipes with a small hole at one end, it is a mixture of powdered zinc

and sulfur that has just the right properties. Teacher organized for us to shoot ours off on a Saturday morning from a deserted sports field behind the school buildings. Mine actually went right out of sight before falling back to earth with a mighty thud. Orgasmic!

We had lots of short quizzes, one or more each week. Grades on these papers were determined in several ways. Most common was for the teacher to mark the papers. The next day, without handing them back, he would graph the distribution of the marks on the blackboard. The class were then asked to discuss the distribution. It was usually a bell curve but sometimes bimodal or highly skewed. A very effective, practical lesson in statistics, the class would next be asked to vote on where the cutoffs for grades should be in the distribution. The top ten percent should be A's, the bottom 10% F's, and so on for B's, C's and D's. Special considerations might lead to a motivated deviation from the standard percentages. Only after the cutoffs were agreed would the papers be returned to let us know what grades we had given ourselves. At other times, he would ask us to pass the quiz paper to the person behind or in front of us to mark. Once we even had to mark our own papers, without having been given the correct answers. Surprisingly, subsequent re-marking by the teacher himself differed only slightly: on average we had graded our own papers slightly lower than he did.

Discipline was a problem at Hixon, as the playground incident recounted above might lead one to suppose. Steps to minimize disruption took several forms. Anyone caught outside a classroom during lesson periods, without a signed note from a teacher, would be sent to the vice principal's office and would likely have to stay after school. Ditto anyone caught smoking on school premises. Drug use was not a significant problem at the time.

But again it was the science teacher who stood out, who pursued discipline most vigorously. In his class, even an inappropriate glance could prove one's undoing. I sat next to Miss Linda Geier, an interesting young lady who also had a fascination for science. We discussed the lessons and what might be expected to appear on the quizzes. One time we guessed at a question, and when it indeed did appear on the next exam paper, I glanced knowingly at her and she returned my look. Unfortunately, the teacher saw us, and promptly failed us both. It was humiliating. But this was not the worst that could happen.

Anyone caught whispering or passing notes (or shooting orthodontic rubber bands) could expect to be called to the front of the class to explain him- or herself. Regardless of the answer, he or she might next be ordered either to sit for the rest of the class period on a stool in a corner with a pointed dunce cap on, or worse, to face a wall with feet about 60 cm out, then to lean forward until only the nose touched the wall; this position would have to be held for 5 minutes. The latter I assure you is an exquisitely unpleasant punishment, both painful and embarrassing. More serious breaches could lead to physical force. Teacher was known on occasion to grab a student by his shirt collar near the throat, lift him up and hammer him against the wall, before sending him to the vice principal for formal punishment.

I mention these experiences at Hixon because they stand in such marked contrast to the situation in public schools today. Teachers now are much more constrained in their actions. Teaching plans have to be worked out in detail and must be approved. Staff are generally forbidden to touch pupils, even to comfort them in times of emotional stress. I dare to suppose, however, that the harsher regime I experienced did me no harm. I do wonder what the soft disciplinary regime

that today's children experience will mean for their world-views as adults.

While seventh grade science was intellectually exciting, astronomy was not on the menu. My interest would have to be pursued outside of school. An unexpected development helped out.

Mother decided it would be important for Eugene and me to learn about money, about how to budget carefully and to manage one's expenditures. Each week on Friday we were to be given $5. We were then expected ourselves to pay for our school lunches, any new toys or games, new clothes as required and so on. We both saved up these allowances conscientiously, but not for the intended purposes.

After six months, Eugene bought a chemistry set, and I sent away for a larger telescope: a 4¼ inch reflector from the Edmund Scientific Co. It cost $79.50 plus shipping, and had an equatorial mount that made following the stars much easier as they appeared to move across the sky. I could see fainter stars too. This was a wonderful development and I spent nearly every clear evening and some early mornings observing. Unfortunately, school clothes were neglected as we saved for more scientific purchases, and after about a year of the new allowance regime, Mother concluded that it would be better if she again bought our clothes for us.

I prevailed on Father to accompany me to gatherings of the St. Louis Astronomical Society, which held its monthly meetings in a seminar room at the Washington University. There I became re-acquainted with Mr. Stuart O'Byrne, of the wooden telescope at 6th grade camp. He invited me to his house in Webster to observe artificial satellites.

Recall at this point that only two years previously, on 4 October 1957, the first man-made satellite, Sputnik, had been launched. The big challenge with all the early satellites was to find out where they had ended

up in orbit. Amateur astronomers were invited to participate in Operation Moonwatch, an initiative of the Smithsonian, to search the skies for wayward satellites. By the time I became involved, professional wide-field cameras were in place to locate new satellites immediately after their launch, but precise orbit determinations were still making extensive use of visual observations by amateurs.

Mr. O'Byrne taught me to use the *Bonner Durchmusterung* star maps and associated star catalogs, in particular to be able to update the stellar coordinates from 1855 to 1950, taking account of the precession of the Earth's rotation axis and the motions of the stars themselves. I was surprised to find that many stars had moved noticeably in the hundred years since the BD was prepared. Our observing procedure was to predict roughly when a satellite would pass overhead and through a selected (by me!) group of stars visible with my small telescope. Then I would note with a stopwatch the exact moment it passed close by a star or between two stars. We would then calculate its position at that precise time, and send the result to the Smithsonian. Every quarter the Smithsonian people sent us the accuracy of our measurements compared with the final orbital determinations. As you might expect, a kind of competition developed among Moonwatch participants. I was immensely proud of generally scoring among the best.

The summer of 1960 saw the Butcher family spending a week with the Arthur Holly Comptons at their summer retreat on a lake in Michigan. Compton had shared the Nobel Prize in Physics in 1927 for his demonstration of the particle nature of light. He had been Chancellor, and was at the time Distinguished Professor of Physics, at Washington University in St. Louis. He was also one of Father's patients at Barnes Hospital. Father had become a well-known and sought-after surgeon (even with a name like 'Butcher'!). His no-nonsense

bedside manner appealed to many of the rich and famous, and he got invited to their events, to go hunting on their estates, or to vacation at their summer homes. I had never met a famous scientist and was very nervous about meeting Compton. He turned out to be a quiet and thoroughly pleasant man, quite willing to talk to me about becoming a scientist. He let me use his library and his small telescope. It was a most encouraging experience. I could imagine myself becoming a famous scientist.

After the summer it was time for 8th grade. By now, a new Junior High School had been built in Webster. Plymouth Junior High was closer to home than Hixon, and the student body was noticeably less rough. An advanced placement stream was available, which meant my math class could move on to algebra and geometry. Otherwise the lessons were mostly unimaginative. I even took a typing class, which turned out to be very useful, and I enjoyed woodworking lessons in a specially equipped classroom. Girls could do home economics but boys weren't allowed to do this obviously useful subject. I brought my telescope and invited others to watch a transit of Mercury on November 7, but no one took the invitation up. At least I was allowed to step out of class for ingress and egress.

I got my first paid job during the year. A new bimonthly magazine, *The Review of Popular Astronomy*, had just begun publication in St. Louis. I was tasked to use the *Nautical Almanac* to prepare evening sky maps and note the times of twilight, the positions of the Moon and planets, and various other phenomena visible with small telescopes. The editor and publisher was Mr. Donald Zahner, who had got my name from the Astronomical Society. I was unsure I could do the work without making mistakes, but Mr. Zahner didn't seem to worry and the work actually went rather well. I do not recall how much I got paid, which certainly wasn't much, but

it was not nothing and I was proud of the opportunity to do the work. As an aside, because I never actually met the man, the lawyer who handled the magazine's legal affairs was a Mr. William H. Webster, who grew up in Webster Groves and was the only person ever to become director both of the FBI and of the CIA.

In hindsight, however, the most important event of the year happened in the spring. It came from an unusual and unexpected quarter and did not occur instantaneously. Now, doctors get sent free samples of medicines for their practice and magazines for their waiting rooms. Father was no exception. In March 1961, he brought home the first issue of a new magazine called *Atlas: The Magazine of the World Press*. It would publish monthly a collection of articles translated from newspapers and magazines around the world. They covered all kinds of subjects, from politics and science to art and literature. Most interesting to me were the views of world events from the perspectives of other countries. Their analyses of the United States were sometimes more thorough and convincing than those in the local St. Louis media. Indeed, I learned the US could be seen as having problems as great and difficult as those of other countries.

Over the next several years, I read each issue of *Atlas* from cover to cover. In doing so, there slowly built in me a revelation not dissimilar to the one brought about by the Air Force Colonel in Sunday School. The United States might in some respects not be the best country in the world. There were extremely interesting and important things happening elsewhere in the world, things that we mostly didn't hear about. I would never again be complacent about the society in which I lived.

In April of 1961, Yuri Gagarin became the first man to go into space. The space race with the Soviets went into full swing. A major push was started to attract smart young people into science and engineering.

A summer school in Physics was run that year at Washington University in St. Louis and I managed to win a place.

We learned some basic physics, of course. For example, I was amazed to learn that a bullet fired horizontally will hit the ground in the same time as a bullet simply dropped from the height of the gun. Obvious in retrospect, it made a grand impression on me at the time. I did hope we would test the idea by shooting a gun, but all we got to do was throw and drop tennis balls from atop a university building.

We learned that computers would be the way of the future, and we should learn how to use them effectively. The IBM company had just introduced its 1620 series computers, and Washington University had bought one. This machine was the first widely affordable, mid-scale scientific computer. It used solid-state components rather than vacuum tubes, and had core memory rather than the drum memory of earlier commercial machines. We were not allowed to touch the machine or even to enter its air-conditioned room. But as homework, we wrote simple FORTRAN programs, typed them onto punch cards, and had them run overnight for us by a trained operator. It took me a frustrating, stressful week to get the bugs out of my first 20-line program. Emotionally, it was not a good introduction to computers, and I have hated punch cards and FORTRAN ever since.

We learned that the Soviet Union was full of smart people, especially in Physics, and we should, therefore, learn to read and speak Russian. We spent an hour each day of the school learning the Cyrillic alphabet and a few Russian words. Thus began a passing interest in the language and culture of Russia.

I noticed that the University had an astronomical dome on the roof of the Physics building. I asked the head instructor what was in it (…an historic 6-inch

Fitz/Clark refractor) and could I please look at it and maybe observe with it? After several replies of "No, it's not open to students," I plucked up my courage and knocked on Professor Compton's door. He remembered me and phoned the instructor right away to ask him to come to the office. I was duly 'introduced,' and it was suggested that the instructor might show me how to use the telescope. Afterwards, the instructor's irritation was unmistakable. I did get to try the instrument out, but the main thing I learned was the danger of going over one's superior's head to get one's way. The lesson would stay with me and be recalled and observed several times during my time as a project manager.

Shortly thereafter it was time to start the 9th grade at Plymouth Jr. High. The year was largely uneventful. We did have an introduction to trigonometry during the last semester, which was interesting and clearly important. But we also spent an inordinate amount of time preparing for the obligatory national exam on the US Constitution. It was largely a year for consolidation in preparation for high school.

I used my time out of school that year to start construction of a larger telescope. It would be an 8-inch reflector, the components of which I wanted to make myself. I wanted in particular to grind and polish the main mirror in our basement at home. I suppose I felt it would be a kind of rite of passage as an astronomer to have built a high quality telescope myself. The main hurdle to be overcome was a result of my father's hands. That is, as a surgeon he relied on the dexterity of his fingers and hands. For years in the evenings he practiced tying knots in suture thread with only one hand. He had his hands insured, and evidently a condition on the policy was that he would not have any power tools in the house. The consequence was not only that we had no power tools, but also no expertise in making things. I invited myself to the home workshops of Astronomical

Society acquaintances, to learn how to proceed. But they of course all had power tools, while I would largely have to do without. This early realization of the importance of actually gaining real-world experience would inform management choices in my later life: One has to do things in practice to build up any real expertise; book learning is rarely enough.

Grinding and polishing mirrors to high optical quality is more art than engineering. I gathered the necessary ingredients: pitch, carborundum, jeweler's rouge, and of course (pyrex) glass. I constructed a pedestal at just the right height for easy manual manipulation of the mirror blank on a full size pitch tool surface. The blank had to be rotated and translated in an appropriate fashion by hand as I walked systematically round and round the pedestal. If I did it right, the front surface of the mirror would slowly take on the desired concave shape. I spent hours working through the various grades of carborundum and then on to a rouge slurry to achieve enough of a polish to be able to test the surface optically. This all went satisfactorily during several months of working evenings and weekends. Finally, the surface had the necessary optical quality but needed a bit more figuring to get the overall shape just right. Then I slipped. Or rather, I let go of the mirror blank to wipe my nose, and it slipped off the pitch and cracked as it hit the cement basement floor. If it was cracked, I was shattered. I would have to start all over. Well, in the end I didn't. I decided I would not have time to complete the mirror myself after I started high school. Father was prevailed upon to purchase an 8-inch mirror with the right specifications. I did finish the telescope, and I enjoyed using it for several years. But I hadn't actually done it all myself and that was an enduring disappointment.

The summer of 1962, before I would start high school, our parents enrolled Eugene and me for a two-

week session at the Ranch Roy-L summer camp in Jonesburg, Missouri. This was a camp for city children where they might experience the joys of farm life. In addition to the usual camp games, horseback riding, campfire barbecues and the like, we learned to milk cows, shovel manure, mow and bale hay, and care for chickens, goats, cows and horses. There were poisonous snakes, ticks and other creepy crawlies galore. You had to be careful dealing with the horses and steers, and several campers did get hurt. When outside, the senior counselor always wore a pistol in a thigh holster. He claimed it was for snakes, which he did dispatch on occasion. But his passion was quick-draw contests. When urged, he would twirl his pistol into and out of its holster just like in the movies. Rather good, I thought at the time.

I attended Ranch Roy-L two summers as a paying camper. The summer I turned 17, I was hired as a camp counselor for a group of 8-year old boys, which job I did for one summer. It was pretty easy, as most of my ten campers were fairly shy. I only really disliked the evening tick inspections before lights out. Each camper had to be inspected in all his cracks and crevices for ticks, and most didn't enjoy the exercise at all. Among the counselors there was good camaraderie, however, which made the summer a pleasure. There was even one female counselor I fell hard for. We saw each other several times after the summer, but in truth we weren't compatible at all and she at least soon realized it.

Senior High School years

To many in Webster Groves, senior high school was a high point in life. There were sports to play, dances and parties to attend, driver licenses to get and second-hand cars to buy, in fact a good time to be had before getting married and finding a job. The CBS documentary, *16 in*

Webster Groves summarized the situation and the general social environment well.

Of the 500-odd students starting the 10th grade in 1962 at Webster High School, about 50 were in two special classes that followed an advanced placement curriculum. The goal from the start for those in this stream was to gain admission to a good university. We were told that our future earnings would scale with how much education we had. The Cuban missile crisis unfolded as we started classes. It brought home the vulnerability of our society and underlined the competitive nature of the world at large. There was no doubt in our minds that highly educated people would be in high demand when we entered the job market. School was serious stuff and the competition for good grades was sometimes almost palpable in the air.

Four teachers made indelible impressions on me during my high school years.

Mr. George Brucker was the mathematics teacher, and would be so for all three of my high school years. He had a special talent for making mathematics exciting and his class was often the highlight of the day. His curriculum took us through trigonometry, analytical geometry and two years of calculus. After me, he in turn taught Eugene and then Nadine, and in the process became something of a family friend. He attended the memorial service at Father's passing in 1989.

Mrs. Yvonne Lanagan was my English teacher in 10th grade. I expected the class would involve English literature, in which I was less than interested. But her forté was grammar, logical exposition, and penmanship. We learned to parse complex sentences. We wrote short essays almost every day in class and longer ones as homework. If she couldn't readily decipher your handwriting, you lost points or were failed outright. If I hadn't studied grammar in French class previously, it would have been a tough slog. But hers was an approach

I liked, concrete and readily understandable, and I was good at it. I didn't much like her as a person, but I have retained and found useful a great deal of what she taught, which must be the mark of a great teacher.

Mrs. Marie Koons taught French. Although she seemed old enough to have retired long ago, she was fascinating as a person. Her French accent was terrible, but we didn't mind because she told great stories of her adventures in life. For example, she told us she had been arrested and lost her pilot's license for flying her private plane under one of the bridges along the Mississippi River. How good is that! We spent a good deal of time on French culture and its influence on the world of diplomacy, and on French literature. She noted all the words in Russian of French origin, and she agreed it was historically time that we should all start learning Russian. She organized a Russian club and ran an after-school, extra-curricular class in the language for interested students.

Ms. Katherine Fitzgerald taught biology to us 10th graders. She was young, had a pleasant face and large breasts. The latter were objects of endless fascination to the puberal mind. She kept a white mouse that she put on her head to rummage around in her bouffant hairdo. At times, mouse would scramble down onto her shoulders and nibble at her ear. Occasionally it would even slip down inside her bosom, much to the delight of us boys. The biology was interesting too. We dissected frogs and crickets and earthworms, and I got interested in using Father's professional microscope at home. I looked at the bugs that grow in pond water, and I especially liked watching paramecia swimming around using their cilia. I perused Father's slide collection of stained cancerous tissues. I did a project to see whether the division rate of yeast cells would be affected by their being in a moderately strong magnetic field (it wasn't). I found that sperm really do look like little tadpoles swimming

about. To complement our study in class of anatomy, I prevailed on Father to purchase an embalmed cat, which I spent over a month of evenings and weekends slowly dissecting in our basement.

We did chemistry in the 11th grade and physics in the 12th. But except for Mr. Brucker's math class, all subjects were generally not very stimulating. Classes such as history, social studies and physical education were taken together with non-advanced-placement students. They brought back memories of my year at Hixon, as did a variety of incidents unrelated to learning. For example, a toilet got blown apart when a student lit a cherry-bomb and dropped it into the bowl just before it went off, flooding the bathroom and into the hallway. Another day a student was busy disrupting class by openly playing with his large switch-blade knife. I made an off-hand remark and got sent to the vice principal's office and had to stay after school; he received a gentle suggestion that it would maybe be better if he waited until after class to bring his knife out in the open.

I became interested in photography, both for taking pictures of celestial objects through my telescope, and also for understanding the rules of composition that make for good photographs generally. I set up a darkroom in the basement at home and spent many hours trying out the various film developing and printing techniques. In one of my few attempts to get involved in a mainstream social activity at school, for a season I took photographs at football and basketball games.

Not one to make many close friends, I did spend time with a couple of age-mates. Many mornings, I walked the half-hour to school with George Fuller, who was also in the advanced placement stream and whose house was on my way. George seemed very knowledgeable about sex. Although too much of a geek to attract the attention of the opposite sex, I was of course very interested in such matters, and I listened carefully to

George's insights. I probably spent most time with David Weber, however. David lived a 10-minute bike ride from my home. We enjoyed going places, tinkering with things, building and flying model airplanes, and listening to gospel and country-and-western music together. Otherwise our interests diverged. I suppose we enjoyed each other's company partly because there was absolutely no competitive element in the relationship, as there certainly was with most of my classmates in the advanced placement stream.

If any single event begins the transition to adulthood in the young American mind, it is the acquisition of a driver's license. I would turn 16 at the end of the 10th grade, so I could take Driver's Ed that year. A room was outfitted with simulators so we could practice driving in the safety of the classroom. First thing though, we were shown a film of car crashes and mutilated bodies. It was gruesome. Presumably this was to instill in us the realization that bad things can happen to you if you don't learn the lessons being taught. Toward the end of the semester, teams of four students and an instructor would go for practice drives in cars specially equipped to allow the instructor to slam on the brakes if required. I sat in the back seat one day when a classmate cut off a dump truck while changing lanes, forcing the truck off the road into someone's front yard. One student pointed this out to the instructor, but by the time he looked back the event could no longer be seen, and we drove merrily on. Funny, the things you remember.

I duly passed the school's Driver's Ed course, took the formal driving test and got my license. I could and did drive the family cars, of which we had two. But as do many young boys with a new driver's license burning a hole in their pockets, I also fancied it would be 'nifty' to have a motorbike. ('Nifty' was the word we used at the time, to be supplanted later on by 'cool' and then 'awesome'.) Father said he wouldn't forbid me to have one,

but he would insist I spend three Saturday evenings observing in the Barnes Hospital Emergency Ward. He explained to me the types of injuries that are typical in motorbike accidents. He must have done so graphically, because I lost interest in the matter and indeed, have never since felt the urge to own a motorcycle.

I also talked to Father about my future. He warned me that there were very few jobs for astronomers. Perhaps I should look at some other science as a career. I had enjoyed biology and my extra-curriculum forays into bugs and microscopes. But I disliked Barnes Hospital. It was full of sick people and always had a strange smell. Surgery seemed rather romantic, but I wasn't sure I could deal with all the blood. Father was most obliging and organized for me to attend a hernia operation. Sitting in an observation gallery high above the operating table, I got a first hand view of the operation, from the initial anesthetic to the final suturing. And indeed, there wasn't all that much blood.

I wondered about medical research, which seemed to offer even less blood. He arranged for me to spend a number of days over several weeks working with his close friend, Dr. Jessie L. Ternberg, at the Children's Hospital. The work involved study of the neurophysiology of the pituitary gland in guinea pigs. These small structures had to be removed from living animals. The procedure was to sedate the guinea pigs with ether, crack open their skulls with a giant nutcracker-like implement, then find and quickly remove the organ and have it freeze dried. A day or so later, the gland would be encased in wax, sliced with a microtome, then examined using a transmission electron microscope. I got to carry out most of the steps myself. Except for cracking the skulls, which was accompanied by a dreadful crunching sound, I rather liked the process. It was quite high-tech but very hands-on. I was especially fascinated by the electron microscope and how it worked. Dr. Tern-

berg was exceedingly patient and helpful, explaining the how's and why's at every stage of the process. I subsequently felt somewhat guilty for deciding medical research was not for me.

University beckons

The summer of 1964 was the time to decide about university. Notwithstanding Father's warning about no jobs, I wanted to be an astronomer. I had read many articles in popular science magazines and knew that a lot of research in astronomy was being done in California, in particular at the California Institute of Technology in Pasadena. There they had the largest telescope in the world, the Mt. Palomar 200-inch. I found an article by Caltech astrophysicist Jesse L. Greenstein in a popular science magazine. It said you can determine the chemical compositions of stars using spectra taken with large telescopes. You don't actually have to go to a star to collect a sample for analysis. You can just measure the absorbing signatures of the different elements in the stellar spectrum and presto! you can see what it is made of. It blew my mind. Astrophysics was what I wanted to do. I decided I would apply to Caltech and study astronomy and astrophysics there.

Of course, California was a long way off, and I might not gain admission. The nearest university that had an observatory and offered a degree in astronomy was Northwestern University in Evanston, Illinois, a half-day's drive away. The director of the Dearborn Observatory there was Prof. J. Allen Hynek. He would later become (in)famous for his work on UFOs (flying saucers), but I knew of him from his involvement with the Smithsonian's Moonwatch project and from popular astronomy articles in *Sky and Telescope* magazine. Clearly, there were interesting things happening at Northwestern. I filled out an application and sent it off.

Father was concerned. I really should consider alternatives to astronomy. Like, maybe, medicine. But in any case something with good job prospects. He agreed to take a day off and drive to Evanston, talk to Hynek about the career prospects in astronomy, and then I could decide what I should do. Professor Hynek was most gracious, gave us a tour of the Observatory and answered our questions. He had my high school record from my application. He said I would certainly gain admission to Northwestern, but should I also be accepted by Caltech, I should choose to go there. They had better facilities and a stronger program. By way of reassurance to Father, he said that the training astronomy students receive makes them employable in many kinds of jobs, not just in astronomy.

Looking back, it was either arrogant of me or very naïve, or possibly a bit of both, to have applied to only two universities. Worry did surface one day when a Caltech professor showed up at Webster Groves High School to interview me. He was passing through St. Louis and Caltech asked him to make a detour to talk to me. He said Caltech not only wanted smart students, it also wanted well-rounded ones. Well-rounded in this case meant being involved in sports, music and other extracurricular activities as well as getting good grades. I told him my hobby and my passion was astronomy and I wanted to be an astronomer. That was why I had applied to Caltech. I had taken piano lessons and played guitar informally, but I was not a sportsman nor was I involved in student politics. At the end of the day, I thought my future might well unfold at Northwestern University.

As my senior year drew to a close, the High School gave out awards. The fellow with the highest grade point average was Valedictorian, of course. He eventually trained as a Buddhist monk in Thailand and now teaches meditation at a retreat in Marin County,

California. The student with the second highest marks got sick and died some years after graduating. I was number three and voted the person in the class most likely to succeed as a scientist. I was awarded a plaque sponsored by the Bausch&Lomb optical company, which was fitting I guess. George Fuller went on to get a degree in chemistry and worked for the multi-national Monsanto chemical and biotech company, before moving to Thailand where he now runs his own business. Regrettably, I lost track of what happened to David Weber.

In the event, I was accepted by Caltech, and I followed Professor Hynek's advice to head west. I do not regret the decision. The following four years would at times be exhausting and depressing, but were also to be punctuated by moments of great excitement and of profound satisfaction.

Historical remarks

The period covered by this Chapter – 1959 to 1965 – was one of great social change in America. We baby boomers, born starting at the end of World War II, were now swelling the ranks of the teenage population. The dress fashions of the 1950s – bouffant hair-styles and knee-length dresses for girls, crew-cut hair and button-down shirts for boys – were making way for mini-skirts and Beatle-length hair. At least they were elsewhere. In Webster, I do not recall ever having seen a mini-skirt except on television, and of the 264 boys in my graduating class, not one had hair long enough to reach the top of his ears. Of immeasurably greater social importance was the birth control pill, which was available from 1960. It was daily the subject of whispered conversation at Webster High. Among the boys, locker room conversations shifted noticeably from worry about pregnancy toward worry about venereal disease.

President John Kennedy proposed a flood of new social legislation, much of which was passed by Congress. Young people talked about joining the Peace Corps, although in Webster only a very few actually did. The first men went into space in 1961, and President Kennedy quickly committed the country to going to the Moon by the end of the decade. We geeks saw a brilliant future ahead of us.

The civil rights movement gathered momentum. It seemed as if the last bastions of Southern resistance to equal rights for blacks would soon crumble. The feminist movement likewise moved onto the national agenda, although it would be 1974 before women could obtain loans or home mortgages in their own right.

Construction of the Berlin Wall in 1961 and the Cuban missile crisis in 1962 brought home the precarious nature of a world with nuclear weapons. Students wondered aloud whether they should have children at all, given that a future nuclear war seemed almost inevitable.

On 22 November 1963, the public address system interrupted class in Webster to announce that President Kennedy had been assassinated. People across the nation would remember for the rest of their lives where they were when it happened. The optimism of the preceding decade drained noticeably from public discourse.

US involvement in Vietnam ramped up. Conscription became an issue for males. We all had to register at age 18 and take an army physical examination. Many considered either volunteering to gain preferential treatment, or marriage, which granted deferment, at least initially. Those of us going on to university were granted deferment until we finished our education. We hoped and expected the war would be over by then.

Chapter 5
The fire hose

I came to sip from the fountain of knowledge and instead caught hold of a fire hose.

– Anonymous Caltech wag

Caltech was full of surprises. The first was that Caltech did not admit girls! How could I have missed that? Had I known, would I have chosen another university? Should I consider applying for a transfer? Female undergraduate students would only be admitted the year after I graduated.

Second, another disappointment: There would be no astronomy courses until the last term of the second year, nearly half-way through the 4-year program. First one had to learn physics and math, in fact much more than I wanted to know. At least my formal supervisor would be Jesse Greenstein, a famous astronomer and chairman of the astronomy department. He would be a source of wisdom and guidance during my years in Pasadena.

Third, the smog in Pasadena was terrible. Red, watery eyes and wheezy breathing were to be common

ailments. It would be early on a Sunday morning two weeks after my arrival before it was clear enough to see the San Gabriel Mountains, looming up just a few kilometers north of the campus. During my Caltech career I played on the varsity soccer team. Our competitions were regularly halted and occasionally even cancelled when the referee couldn't stop coughing. California's auto emission controls would take another ten years significantly to improve air quality in the Los Angeles area.

The first formal event of the Caltech experience was Freshman camp. In August, before a September start of classes, the year's intake of 200-odd new students from around the country and the world got bused to cabins in a nearby national forest. There we were told what would await us during the coming four years.

A kindly-looking, gray-haired gentleman, the President of the university, Lee DuBridge, started the camp off. He welcomed us and said he was pleased we had decided to join the Caltech community. He paused for a moment and then said, "Now, I want you to look at the person to your left. Next look at the person on our right. One of you three will fail to complete your Caltech education. Caltech is arguably the most difficult school in the country." He said we all had the brain-power to succeed, but to be the best requires extraordinary dedication, and many of us would find we did not have it. We may have been among the smartest persons at our high schools, but here many would find out what it feels like to be among the dumbest in the class.

At the time, it was hard to know what to make of such a friendly introduction. Ultimately, about 30% of my year's cohort did drop out for one reason or another. A joke that did the rounds: "Even if you flunk out of Caltech, you can always get a degree at MIT!" The rivalry between the two universities was, and indeed remains, very strong.

At the camp we also learned about the Caltech Honor System. Students were expected to be scrupulously honest in all things, also to report any suspected incidents of dishonesty by others. Cheating on exams, for example, if confirmed, led to immediate expulsion from the university. The positive side of the Honor System was that many exams could be undertaken in the quiet of one's home or dormitory, whenever one felt one was ready. Mandated time limits had to be observed, of course, as did whether one might consult reference material or not, but no one else was present to check up on you. Generally this turned out to be a most civilized approach to testing, and in fact, very little cheating ever occurred.

I quickly discovered, however, that it is relatively straightforward to make exams for which no reference material is helpful. Indeed, the most difficult exams by far were those that allowed consultation of any reference material one wanted. Such exams often required lateral thinking, whereby a technique studied for one situation could be applied in another. We studied the diffusion of heat in solids, for example, and one test required realization that the same equations, suitably modified, apply to the diffusion of neutrons in reactor piles. Another exam supposed we would see how to apply the mathematics of group theory, which we had studied in elementary particle physics, to derive the energy levels of the hydrogen atom. Particularly nasty were some tests employing multiple-choice questions. In high school it always paid to guess which multiple-choice answer might be correct; there was no penalty for guessing. At Caltech, any, all, or none of the possible answers to a question might be correct, and wrong guesses incurred penalty points; negative test scores were not unusual in such cases.

Thanks to Mr. Brucker at Webster High, I tested into the advanced math stream. Initially very proud of

this, I quickly discovered that advanced math at Caltech meant proving abstract theorems, the utility of which was not evident. I learned I cared about using mathematical tools to solve problems, and very little about proving fundamental theorems. Indeed, I would learn most of my math in my physics and engineering courses.

All first-year students were required to live on-campus. I was allotted a room at Ruddock House, one of several modern dormitory units. Each room was shared, having two beds, two desks, two cupboards and a sink. Each hallway had showers and toilets. Meals were taken at set times in a common dining area, and a lounge area had a public television and the only telephone (this being long before the advent of mobile phones).

The inhabitants of Ruddock House were a mixed bunch, both as regards study areas and family backgrounds. The engineering students could be counted on to show you how to make long distance telephone calls without paying, and would organize strippers and unlimited beer at the annual parties. Math students were more refined, and would provide musical events and mentor struggling classmates. Physics students seemed rarely to emerge from their rooms.

Some new students had trouble adapting. One in my year, from New York, found the dormitory unbearable. He had wall-to-wall carpet installed in his room to make it more livable, but even so couldn't adapt to sharing with another student. He left after three months.

Sophomores (second year students) were expected to give freshmen a hard time, both during an initial 'hazing' period and at random times subsequently. A student had died during a hazing prank several years previously, so hazing was fairly tame when I was a freshman. I believe I had to undertake a treasure hunt around the campus in my underwear.

Some students earned part of their keep by waiting on tables during meals. New waiters were treated

mercilessly. When a food platter was used up, it was not uncommon for a diner to yell for more, hold the empty platter behind his head, and, if it wasn't grabbed within five seconds, would let it drop and break. Of course, the waiter would then have to clean up without missing a beat of service to other tables. Food fights generally were limited to those meals where the food was voted inedible by a majority of diners.

Final exams at the end of each term were typically 3 hours long. Those exams to be held in classrooms would start at 9 a.m. or just after lunch. Many students would 'cram' until early morning, then fall asleep. To ensure that those with a 9 a.m. start would awake in time, the dormitory hallways were outfitted with a high power sound system. Then, every 7 a.m. all during finals week, Wagner's *Ride of the Valkyries* would reverberate at an ear-splitting level throughout the dormitory. Even today I suffer a burst of adrenalin whenever I hear that music.

Each spring, seniors (4th year students) would depart campus on Ditch Day, leaving their rooms locked using some kind of ingenious mechanism. All Caltech students learned early on how to pick the normal room door locks, so these mechanisms had to be clever. They could be electronic, mechanical or puzzles of various sorts. Sophomores were expected to spend Ditch Day figuring out how to get into the rooms and play some kind of prank in any successfully entered room. These pranks could, for example, be the (re)assembling of a car in the room, or dumping a load of sand or paving the room with asphalt, or furniture could be attached to the ceiling, beds removed up into a tree in the courtyard, or the room could be locked with a new and different clever mechanism for the returning senior to puzzle out. It was good fun.

Freshmen were required to follow a course of physical education, with a view to participating in a

sport in later years. Father had pressured me to take up some sport and not focus exclusively on study. I seriously considered fencing, which was the sport of Halton Arp, a famous astronomer at the Mt. Wilson and Palomar Observatories there in Pasadena. But I lost all my introductory practice matches, so fencing was clearly not for me.

In the end, I settled on football (soccer). Training was for a couple of hours on two afternoons a week and with games on the weekend, so it wouldn't be too much of a demand on my study time. And there were few enough players that I could expect to play in most games. Indeed, I made the varsity team, which, Caltech being an engineering school, was called the *Beavers*. I played either half-back or full-back. Our opponents were local high schools and community college teams, and we lost most of our matches. I did play one match in the Rose Bowl, which is famous for hosting the premier national college football (gridiron) game every New Year's Day. The stadium had a seating capacity of 100,000 and was the largest in the country at the time. Of course, all but maybe 20 seats were empty for our match; still, I can say I played in the Rose Bowl!

The team was composed by and large of foreigners. This made it interesting, of course, but occasionally led to cultural incidents. A kerfuffle arose when a newly arrived student from Brazil showed himself to be an excellent center-forward (spits), but he wanted to play barefoot. Evidently he had never played with shoes and he felt they crimped his style. There seemed to be no rule that football shoes were required, only that any metal cleats couldn't be longer than a certain number of millimeters. In the end, the fellow lost out and had to wear shoes.

I played varsity for three seasons. In my senior year, I decided it was taking too much time. I joined an unofficial team that played once a week, social matches

on Sundays. Most of the players were Chinese and if we won the game we all retired to a player's house for Chinese take-away. I remember this because the favored delicacy after a win was pickled ducks' feet. You eat these by popping the foot and ankle whole into your mouth, sucking the bones out of the skin and spitting them out, before enjoying the pickled remains. I never developed a taste for the things and was never too unhappy when we lost a match.

The above remarks serve as preliminaries to a commentary on the main purpose of being at Caltech: study, study and more study. It was expected that students would spend between 50 and 60 hours per week on lectures, tutorials and homework. I must have done that most weeks, but what I remember most is that there was precious little time for anything other than study. Indeed, one quickly concluded it would be impossible to complete all the work assigned, so one learned to apply a kind of triage, focusing attention on those subjects most in need of good marks – *e.g.* physics – while neglecting those that were less than quantitative and readily able to be bluffed – *e.g.* humanities – and tending to the remaining only if there was any time left over. In this situation, it was probably good there were no females at the Institute, nor indeed any nearby co-ed institutions.

The competition for grades was fierce, although there was hardly any discussion among classmates about grades, nor for that matter any cooperation on homework or during preparation for final exams. I recall several graduate students and faculty remarking that they would not send their children to Caltech, because the undergraduates had to work too hard and the competitive pressure was too high.

I lived through it, of course, all four years. A saving grace was the extra-curricular, intellectual stimulation that was readily available to motivated students.

Each week on Monday, for example, the Caltech administration published a calendar for the week, listing the colloquia, not only in astronomy but also in physics, biology, chemistry etc. I could and did start hearing about modern astronomy and astrophysics right away by attending these colloquia, as well as learning a little about forefront research in other sciences. Perhaps it is germane to record a few words about the science of the time.

Quasars had just been discovered (1963) by Caltech astronomer, Maarten Schmidt. I experienced first hand the subsequent effort (by Caltech's Kip Thorne and others) to develop the mathematics required to describe the physics of the quasar power source, believed then as now to be a massive black hole. The cosmic microwave background had just been discovered (1965), which was taken by most Caltech faculty as proof of the Big Bang model of cosmology, and as definitive argument against the steady state model. It led immediately (1966) to Willie Fowler and the Caltech nuclear astrophysics group calculating that most of the helium in the Universe must have come from the Big Bang itself (and not from stars, even though stars shine by converting hydrogen into helium). Caltech physicists Gell-Mann and Zweig had proposed (1964-65) the existence of quarks, fractionally charged particles that make up protons and neutrons. There was great debate during the colloquia as to whether quarks could be real or merely a mathematical construct, a useful idea for performing calculations but not real. Then they were discovered at Stanford (1966), opening a new chapter in high-energy particle physics. Physicist Robert Christy had been responsible for designing the explosive core of the first plutonium bomb at Los Alamos during World War II, and he used his knowledge of implosion physics to carry out improved, non-linear calculations of the pulsations of Cepheid variable stars (1966), finally to put the distance

determinations of nearby external galaxies on a firm theoretical footing. Pulsars were discovered in Cambridge (1968), the first being humorously dubbed LGM-1 (for 'Little Green Men-1'). Caltech theoretical physicist, Kip Thorne, quickly demonstrated that the only plausible sources would be rapidly spinning, magnetized neutron stars, and then he worked out the strange properties of such objects, which may be seen as atomic nuclei held together by gravity rather than by the nuclear force.

Not all the excitement was in physics and astronomy. Some of the biology colloquia were particularly fascinating. A Caltech group fabricated separate bits of a bacteriophage virus (T4), clearly just molecules and very much not alive. When they were assembled, however, the virus began to function, infecting *E. Coli* bacteria and performing just as if it had been formed by naturally occurring reproduction. This led to a considerable discussion subsequently on the nature of life, whether a virus is alive and whether a divine 'spark' is required to have an organism come alive. Evidently not, was the conclusion. Another group showed a spectacular time-lapse movie they had made of slime molds. These are single cell creatures who, when food becomes scarce, cluster together and differentiate in function to form a multi-cellular organism that can detect and move toward food sources, then to reproduce by emitting spores that can be carried long distances on the wind. Discussion centered on what this could mean for the evolution of multi-cellular life in general.

You can see that this was an extraordinarily stimulating environment for a young, aspiring scientist, quite apart from the formal academic program.

In the middle of my freshman year, Caltech professor Richard Feynman shared the Nobel Prize in Physics, for showing how to calculate the electromagnetic interactions between quantum particles. He had just fin-

ished giving the famous Feynman Lectures in Physics, from which the three volumes of textbooks of the same name resulted. They were my bibles during the first two years of Physics courses. They were a joy to read and study, because they presented the material in a most intuitive and understandable way. On the other hand, they assumed that understanding of the physics would lead naturally to an ability to solve problems, to see intuitively how to adapt the equations presented and formulate approaches to finding numerical answers. Feynman clearly felt that once a basic idea was understood, practical application was a trivial exercise. This was frequently not the case for us mortal beings, and most of us also had more conventional physics books on our shelves to guide our problem solving.

My formal introductory course in astrophysics started in March 1967, with Greenstein lecturing. It was both exciting and perplexing. Exciting because I was finally doing what I came to Caltech to do. Perplexing because Greenstein used chalk on a blackboard to present the material, had terrible handwriting, and he never labeled any of his graphs. Evidently, we students were expected already to have enough general background to know what was being plotted against what. It took several lectures before it became clear that Greenstein was using a different system of units from those we had learned in Physics! All the astronomers were using CGS (Centimeter-Gram-Second) units while physicists used MKS (Meter-Kilogram-Second). And a generous dose of history had astronomers using 'magnitudes' instead of 'flux', 'parsecs' instead of 'meters' or 'light-years', 'gauss' instead of 'tesla', 'ergs' instead of 'joules' and so on. I think it was the only time when classmates worked together to figure out what was happening in a course.

Other lecture courses in later years also left indelible imprints. Disillusioned with pure mathematics, I tried engineering math. I learned to calculate the

stresses in bridges, and was witness to an exciting new attempt to design tall buildings able to withstand strong earthquakes. Caltech was in the process of building a new central library. At ten stories, it was the tallest building in an area that regularly experiences earthquakes. The building was to be placed on a system of damped springs – very big damped springs – and be designed such that its modes of oscillation would dissipate earthquake energy without causing structural damage. During construction, to verify the calculations, the naked structure was outfitted with a system of sensors and was shaken with electric motors having off-axis masses. When the tests were completed and the results judged satisfactory, the building was fitted with its external wall panels, windows, doors and the like. Just after I left Caltech, an appropriately large earthquake did occur. The structure survived, of course, but many internal bookshelves and cabinets collapsed, and some external cladding panels and windows came loose; luckily no one was injured by the falling debris.

A self-study advanced course in Astronomy let me read for academic credit the *Astrophysical Journal* from 1950 to 1966, something that was still possible at the time. It would not be for much longer, unfortunately, as government funding began requiring instant and continuous publication regardless of whether anything had been learned. This study hooked me on stellar and galactic evolution, subjects that would remain the main threads of my research career.

I learned nuclear astrophysics from Nobel Prize winner, Willie Fowler, who in the mid-1950s together with the Burbidges and Hoyle had convincingly shown that the origin of the chemical elements must be the result of nuclear reactions in stars. The course material was fascinating, but I also recall the lectures were so popular, even though they were given at 08:30 in the morning, that students would sleep in the lecture hall

the night before, to make certain they wouldn't miss the lecture. It became clear to me that the nuclear physics was undeniable – that is, that certain reactions must have led to the creation of certain elements and that they might plausibly be expected to occur inside stars. But where and when those reactions had actually occurred in the Universe was still a matter of conjecture. Only astronomical observation could reveal the history of the actual build up of the elements, which would be intimately tied up with the history of star formation in galaxies and of the formation and history of galaxies themselves. I saw an exciting future for myself in trying to unravel this history.

That future would necessarily involve spectroscopy of the starlight from stars of different ages and compositions. So I took a course in atomic and molecular spectroscopy, subjects left behind by the physics community in the 1930s. It was given by a solar astronomer, and included the history of electron orbit calculations (which actually would prove useful to me later in understanding the orbits of stars around the Galaxy). I learned how to analyze the energy level structures of many atomic species and to calculate line strengths without recourse to the use of a computer. I found I enjoyed the course immensely, but it also engendered a healthy skepticism of the quality of much of the available experimental atomic spectroscopic data and any stellar abundance analyses that relied on them.

During the first term of my sophomore year, a wonderful thing happened. I broke my leg during a soccer match! This may not seem especially wonderful, but it turned out to be so. I missed several lectures and had to go up to each lecturer in my full-length plaster leg cast to get the assignments I had missed. I also got to sit in the front row of the lecture rooms with my leg very strikingly present. I thereby became recognized by and known to all my lecturers. By this time I had lots of

questions and was keen to talk to senior astronomers both at Caltech and at the offices of the Carnegie Observatories, which were located several kilometers away (the astronomers there were as famous as those at Caltech). I wrote my questions on used computer punch cards and carried them around with me, so whenever I met an astronomer I could pose the most urgent of them. Everyone was willing to talk to me, and then didn't forget the young student with the broken leg and computer punch card questions!

Of particular importance to my future was an acquaintance with Allan Sandage at Carnegie, who was impressed that I would walk the 3 km distance to his office on crutches with my leg in a cast. At the time he had taken over the program started by Edwin Hubble of measuring the distance scale of the Universe, and I was fascinated by how he was extending the work to allow the geometry of the Universe to be measured. Sandage would be a font of career advice and contagious enthusiasm for observational astronomy for the next several years. He would also be instrumental in my decision to go to Australia for my PhD.

My physics lecturer at the time was Gerry Neugebauer. He ran a research group in the Physics Department doing infrared astronomy, which was a very new and promising field. Using the telescopes at the Mt. Wilson and Mt. Palomar Observatories, the group was discovering previously unknown objects hidden behind dense clouds of dust in the Galaxy. It was also carrying out the first moderately deep, infrared sky survey, using a specially built telescope at Mt. Wilson. Neugebauer let it be known that his research group had funds to employ part-time undergraduate research assistants. This was something the astronomers didn't do, so I said right away that I was interested. This involvement would define the rest of my time at Caltech and, indeed, strongly

influence the direction my professional career would take.

Just as the Feynman lectures in Physics were an introduction to a wide spectrum of physical phenomena, so too was the practical training of physics students broad and comprehensive. I learned to work with lathes, drill presses and the like in the machine shop, to solder electronic components and test the functioning of circuits, and to program on Caltech's newly acquired IBM-360 mainframe (most of my calculations for coursework at this time were with a slide-rule or using tables of logarithms). I learned I enjoyed the practical process of designing and building instruments as well as using them to observe the heavens. From my sophomore year, I worked in the infrared group part-time during term and full-time during my summers.

I was introduced to the 62-inch telescope on Mt. Wilson, and I took my turn operating it on weekend nights and during subsequent summers. It was an instrument built by a Caltech physics professor, Robert Leighton, whereby he poured epoxy resin onto a spinning back-structure form, such that the liquid epoxy spread out into the desired parabolic shape as it hardened. A clever approach when imaging quality need not be particularly high, it only had one drawback. When put into the aluminizing chamber of the nearby 100-inch Hooker telescope, the epoxy outgassed and gummed up the chamber, leaving a dreadful mess to clean up. When I came on-board, the telescope was in the middle of its survey of the northern sky. It scanned the sky automatically, only requiring human intervention for 7 minutes each hour, then to measure several standard stars for calibration. So I could spend most of my time operating the instrument doing homework, or visiting with astronomers working at either the nearby 100-inch or 60-inch telescopes at the Observatory. I learned a very great deal from the latter visits, both about the tricks of

observing with large telescopes and about the sociology of astronomical science, as well as who was doing what in astronomical research. I was to become acquainted with astronomers from many countries, with whom I would stay in occasional contact throughout my career. I became friends with two of the night assistants, with whom I also maintained contact in later years.

Digital electronics was just starting to appear at this time. Visible light photomultiplier detectors on the larger telescopes used digital pulse-counting circuitry, but the infrared detectors were all analog systems. Survey data from the 62-inch was registered with a chart recorder, to be digitized later downtown by an attractive young lady, before being calibrated and analyzed. The analog electronics required especially careful circuit design, in particular because rigorous separation of signal and chassis earthing was required. The Observatory shared Mt. Wilson with very high power (analog) television broadcasting transmitters. Heavy metallic earthing mesh had to be employed around signal cables, and it became my job to connect this chassis earth to the telescope, during which operation there was often a loud crack! and an accompanying spark easily 10 cm long. It was a constant and graphic demonstration of the need to consider circuit designs also at the system level. These lessons would come in handy in later life when digital circuitry became so fast that analog effects again would assume importance in circuit design.

I became fairly expert with the infrared detectors and was allowed to assist Caltech astronomers on their observing runs on the 100-inch and 60-inch telescopes. These telescopes were owned by the Carnegie Institution, but were shared with Caltech, who in turn allowed Carnegie astronomers access to Caltech's 200-inch at Mt. Palomar. The Mt. Wilson telescopes were fascinating because they had been involved in several fundamental discoveries. They had been instrumental in

showing that galaxies are distant systems and not nearby nebulae within our own Milky Way galaxy, and that the Universe is not static but expanding. Each telescope had a night assistant to look after the telescope, leaving the observers free to worry about their instruments and observing programs. Observing ceased at midnight for an hour, while observers and night assistants retired to a central shack for midnight lunch and conversation. All observers stayed at the 'Monastery', a dormitory on the mountain that only recently had done away with a formal dress code for dinner and had even begun to permit women to stay.

The 60-inch and 100-inch telescopes dated from the early 1900s, so their technology was from that era. For example, their electrical systems were all Direct Current. Electrical switches were large DC solenoids that gave off green sparks when thrown. A back-up diesel generator had four large cylinders, each of which had to be started separately by hand. First a large fly-wheel would be pushed into rotation; the first cylinder would then be charged with fuel and ignited (boom - - -); then the second (boom boom - -); then the third (boom boom boom -); and finally all together in sequence. It was grand to see the thing go into operation! The telescopes floated on mercury to relieve their polar axial bearings (modern large telescopes are supported by high pressure oil bearings, but hydraulic engineering was insufficiently developed in the early 1900s). The mercury leaked on occasion, and one night assistant was forced to retire with severe mercury poisoning. It was my first exposure to a renowned academic institution that didn't look after its staff properly.

To point the telescope at a star, a complex process was required. You had to precess the star's coordinates to the current date, then use microscopes to inspect visual vernier scales on the telescope's axes, which allowed the telescope to be set to the appropriate declination and

appropriate angle from the meridian. Next one had to calculate the expected sidereal time when the object would be at that angle, and then wait for the sidereal time to match the calculated value. Just before that moment, one had to turn a wheel to engage a mechanical clutch to lock the telescope to its clock-drive. If you did this correctly, the desired star would appear in the center of the field of view of one's instrument. It took a lot of practice to get it right. One good thing the digital world brought was encoders on the telescope axes that eliminated the need for this particular skill.

The clock-drives on both the 60-inch and 100-inch employed falling-weights and centrifugal governors. These worked well and had the great advantage of being completely silent. The night assistants would set up stereo sound systems that filled the domes with classical music. It made observing very romantic, even on bone chillingly cold nights. That is, until digital drive and data systems were put in, toward the end of my time at Caltech. These made the observing process somewhat more efficient, but also made so much noise it was like working at the Caltech computer center. It became impossible to enjoy the background music. The price of progress, I guess.

I assisted twice with observations at the 200-inch at Mt. Palomar, the largest telescope in the world at the time, once with Greenstein and once with Neugebauer. Greenstein confided that in his view the Universe is so large and unexplored that you would have to be completely incompetent not to discover something new with this telescope, even if you just pointed it at a random piece of sky. But the pressure on access was so great that even postdocs rarely got to observe there. So I felt fortunate to have been allowed to be present at all.

Now, tuition at Caltech at the time cost just over $5000 per year (now that figure is $40,000, having roughly kept pace with inflation). Various fees and liv-

ing expenses added half that amount again to the costs of a Caltech education. A physician, Father earned too much for me to qualify for a tuition scholarship, but with my job as a research assistant I was able from sophomore year to cover accommodation and other living costs. The summer of 1967, I moved off campus to save money, first to live by myself, then in the fall to share an apartment nearby with other students.

In the first instance, these were Ed Groth and Tom Soifer, Caltech students a year ahead of me who were also working in the infrared group as research assistants. They later became professors of Physics, Ed at Princeton, Tom at Caltech. They graduated at the end of my junior year and thereafter I shared the apartment with Roger Chevalier and Doug Richstone, both astronomy students a year behind me. Roger became a professor of Astronomy at the University of Virginia, Doug professor of Astronomy at the University of Michigan. My other good colleagues and friends during these years were Henry Tye, a physics student from Hong Kong who later became professor of Physics at Cornell; George Waller, a physics student of American Indian background, who later went to work designing nuclear bombs for the US military; and Stephen Hadler, a biology student who became a Deputy Director at the Center for Disease Control in Atlanta.

In hindsight, I have to conclude that the value of a Caltech education generally lived up to its promise. Most of my classmates in Physics and Astronomy ended up in successful research careers and ultimately in influential positions.

In the end, I graduated in the allotted time, in June 1969, as a Bachelor of Science with Honor: my grade point average was 3.3 (out of 4.0). I was ranked number 32 out of a graduating class of 157, and was first among the 11 Astronomy majors. I was satisfied with my performance overall, but at the same time I had

soured on the highly competitive and individualistic society I had encountered, at Caltech in particular and in California and the USA in general. I knew I had to go on to obtain a PhD if I wanted to work as a professional astronomer (Sandage called it the 'union card' for astronomers). Initially, I was in a quandary as to where I might go for this next phase of my education. I applied to several US graduate schools, but my preference became Mt. Stromlo in Australia. Why that was the case is worth a few words of explanation.

During the course of my junior year, Neugebauer had begun to assign me to look after visiting astronomers from other institutions, who came to Caltech to learn the practical art of doing infrared astronomy. Of personal significance was Harry Hyland, who came on a postdoctoral fellowship to work for a year in the infrared group. Harry had just finished his PhD at Mt. Stromlo Observatory in Australia, and while we worked together he told me all about life there. He said that Astronomy was not taught formally anywhere in Australia and that there were no lecture courses at all at Mt. Stromlo. Graduate students were given four years to do thesis research, with the corollary that students were treated pretty much as staff members. Indeed, they got paid at a higher level than typical graduate student stipends in the USA. I was fed up with sitting in lecture courses and taking exams, so this sounded almost too good to be true. I was soon sold on going to Mt. Stromlo, and hoped I would be accepted to do graduate work there. I knew that Sandage was a friend and colleague of the Mt. Stromlo director, Olin Eggen, and when the time came, I asked him and several Caltech faculty to write references.

They must have been good references, because I received an offer by telegram shortly after applying. I accepted right away by return telegram. Unfortunately, actually getting to Australia would be complicated by

the war in Vietnam. An aside to explain that situation is also in order here.

When young men turn 18 in the US, they have to register with the Selective Service System (they still do!). This government agency operates local draft boards in towns across the country. These boards administer the process of conscription, which is into the US Army and according to the needs of the Army. During my Caltech time, the war in Vietnam escalated and increasing numbers of young men were being conscripted. In total over two million men were conscripted for that war. Many others volunteered for another service – Navy, Air Force or Marines – rather than face becoming a poorly trained foot soldier slogging through the jungles of South-East Asia. Some hundred thousand men left the country rather than serve, mostly to Canada. Draft boards in the 1960s had quotas to meet but also had considerable discretion as to whom they would identify for call-up. Initially, students such as myself who were attending an institution of higher education were exempt, until they finished their education. In 1967, this exemption was removed for graduate students, and it seemed almost certain that I would be drafted immediately following my graduation in June 1969 to fight in Vietnam.

As graduation approached, it was already obvious that the US could not win the war in Vietnam, which had also become exceedingly unpopular at home. I did not wish to be conscripted into the Army for what seemed a complete waste of time, as well as being unpleasant and possibly downright dangerous. The Caltech administration helped all its students who wished to do so to undertake legal appeals designed to delay call-up as long as possible. I toyed with the idea of joining the Air Force and of trying to be assigned to work at the Air Force Research Labs in Cambridge, Massachusetts, but Neugebauer, bless his soul, knew about the

environment there and talked me out of the idea. He also assured me of a research assistant's job after graduation until my situation might finally be sorted out. Caltech allowed me to enroll as a graduate student while my appeal was being processed.

Australia was then as it is now a staunch ally of the US in matters military. The Australian National University, of which the Mt. Stromlo Observatory is a part, let it be known that I could take up my appointment at the Observatory only when I could produce a letter confirming that I would not be conscripted. This complicated matters, but the Observatory agreed to hold the position open for me, at least for a while.

Luckily, the situation resolved itself late in 1969, when the discretionary power of local draft boards was removed and a national lottery was instituted. Birthday dates were drawn on 1 December, supposedly at random, and the order in which a date was drawn was used to fix the order of call-up. As I listened carefully to the draw on the radio, I was dismayed when all the early August dates were being drawn early. In the end, all fit young men with birth dates from 1 August to 10 August were drafted, except for those born on 3 August, my birthday. There was, of course, analysis afterwards, which suggested that the draw could not have been truly random. Even so, the draw was not held anew, much to my relief. The Australians accepted the result without question and I could prepare to leave for down under.

Digression: the Summer of 1966

Much of the summer following my freshman year at Caltech was spent in France. I had decided I would not be taking any further language courses and wanted to make use of my high school French before it had completely dissipated. I wasn't keen on organizing a trip by myself, so I applied to an organization called *The Experiment in International Living*.

The Experiment set up cultural immersion programs for small groups of American students in several countries. The program I joined involved three-week individual home-stays with French families, followed by traveling around France together with a group of eight American and five French young people. A high school teacher led the group, one Barbara Tatum from Silver Spring, Maryland. Her French was fluent, if her accent and grammar challenged, and she had boundless energy, which she put to good use both in dealing with the French in general and with her eight brash teenage charges. The group derived from a wide diversity of backgrounds and included history, art and commerce majors. I was one of two science majors in our group. I was in my guitar phase, and enjoyed supporting the evening singing sessions organized by Barbara.

We met up in New York for prior orientation and then embarked on the *Aurelia*, an aging passenger liner, headed for Southampton and Le Havre. The ship dated from before the War and had no stabilizing fins, so we got used to our meals occasionally sliding across the table. It took five days of boredom to arrive in France, and the crossing cured me of ever wanting to make vacation cruises. After arrival in Le Havre, we went by train straight to Paris and on to Lyon, our final destination.

We were taken right away to our assigned French families. Mine was with Professor Paul Santy, who lived with his daughter and her 10 year old son, in the nearby town of Ecully. The house was quite large and of a Victorian architecture that reminded me of the haunted houses in Disney films. It turned out Dr. Santy was a famous pioneer in thoracic surgery, even having a local main street named after him. Seventy-nine years old, he was still attending at his clinic most days. In my youthful arrogance, I was not much impressed – after all, my own father was a famous surgeon as well, in my eyes at

least. With hindsight, I wish I had learned more about Santy's career and work.

All intercourse in the host family surroundings was to be in French. Unfortunately, I was still mentally translating from English. On arrival, I was in need and asked if I might use the bathroom (*salle-de-bain*). I was duly shown the bathroom – which had a bath, of course, but no toilet! The whole of the home-stay period I found functioning in the foreign language very stressful, and I was exhausted at the end of each day. It was particularly frustrating that I could not express myself with precision; this was a new situation for me and I felt downright stupid much of the time. On the up side, I would henceforth forever sympathize and be patient with those struggling to speak English as a second language.

Life in the Santy household was generally relaxed and pleasant. Most mornings began with a *baguette*, butter and jam, and *café-au-lait*. Some days we went into town, others I did sightseeing with the other Experimenters and our French age-mates. Dinner at home was always a sit-down affair, with a maid serving several courses: soup for starter, then fish or meat, followed by a course of one or more vegetables, a salad course, then finally dessert. Wine with dinner was *de rigueur*; even the 10 year old had a glass, although his wine was diluted with water.

The contrast with American home life was evident, but certainly not bothersome. For example, at dinner most American families, if they eat together at all (like mine generally did) started with salad, followed by or together with meat or fish and vegetables that were served all together on one plate, then a separate dessert course. At least in Missouri, wine was rarely on offer, possibly because the local wines were mostly blueberry, blackberry, apricot and the like. With our home-stay families, we all were admonished to remember to save energy by turning off the lights and closing the doors as

we left rooms. Saving energy was something most of us had never encountered at home.

On most matters, Madam was tolerant of my ignorance, and patiently answered my queries about French life, customs and language. She pointed me to the Asterix and Obelix comic books, which are delightful stories of ancient Gauls who could consistently best Caesar's so-called invincible Roman legions.

Unfortunately, a member of the extended family became ill, and at the end of the first week I had to shift to another home-stay family. This one lived outside Lyon in a proper, real-life *château fort*. In truth, it was a bit of a ruin, but it did have a wonderful history. The main structure dated from the late thirteenth century, built by a member of an influential aristocratic family, one Girard de la Palud, *chevalier* and *seigneur* of the fiefdom of Richemont. It was plundered in 1595 during the French Wars of Religion. These wars led to the famous Edict of Nantes in 1598, which granted Protestants civil rights; then in 1685, Louis XIV rescinded the Edict, leading to mass emigration by Protestants. I note this specifically because that wave of immigration may well have included early ancestors of my own Butcher line.

The agrarian uprising early in the French revolution, the so-called '*Grand Peur*', saw the château attacked, and the scars from cannon shot can still be seen on the outer walls. It was renovated in 1830, only to suffer a major fire ten years later that destroyed most of the auxiliary buildings. A fire in 1947 destroyed much of the roof; the owner at the time, Marcel Veron de la Combe, repaired the damage and subsequently his daughter, Marie-Pierrette de la Celle, renovated the living quarters to the state in which I found them.

Mme de la Celle, who was separated from her husband, was my host together with Rosaline, one of her children. Daily life with these members of the old aris-

tocracy proved not much different from life with the Santys. My one vivid recollection is of the bathroom I was to use, located on the top floor of one of the towers. The only restriction I had in moving about the château was that, should the large barn owl, who had taken up residence in the bathroom, be present, I was not to enter. Any baths had to be taken late at night when it was out hunting.

As the home-stays ended, we began travelling around the country, camping or staying in youth hostel accommodation. We headed first to Brittany. Alas, my recollection of this part of the trip is hazy. Of the places we visited, only three stand out in memory: the village of Carnac – with the world's largest collection of pre-Celtic standing stones, dating from well before 3000 B.C.; Quimper – where we stayed in a youth workers hostel and had a party with the locals; and Mont Saint-Michel – the picturesque, medieval fortress and town on the coast, that is cut off at high tide from the mainland. We were surprised to hear Breton spoken, a Celtic language related to Cornish, and to come across bagpipe-like musical instruments, both observations making evident the close connections to ancient Britain. I was intrigued by the occasional, obviously pagan, shrines in this very Catholic province, which were found along out-of-the-way country roadsides. These were all bits of ancient European civilization still lingering in the modern world, and have stimulated my interest in European cultural evolution every since.

From Brittany it was on to the bright lights of Paris. Like generations of Americans before me, I fell in love with the city. Engraved in memory are: Notre Dame cathedral on the Île de la Cité; La Chapelle with the sun streaming through its stained glass windows; the art scene at Montmartre; my first opera – Offenbach's *Tales of Hoffmann* at the Opéra Comique; jazz at

a left bank night club; and the city by night on a *bateau mouche*. I was ready to spend the rest of my life in Paris.

Several of our number were art history and architecture majors, and I learned from them about the manufacture of medieval Roman and Gothic arches, flying buttresses, and the meanings as well as the purposes of the gargoyles on the churches. The evolution of stained glass window technology occupied us for many hours of discussion. In general, I can take or leave sculpture, but the Rodin museum, under the tutelage of a passionate and well-informed art student, was a highlight, even surpassing the impressionists in the Louvre for me.

Much too soon, our stay in Paris came to an end, as we had to catch a plane home. By train to Luxembourg, where we took an Icelandic Airways flight to New York – with intermediate landings at Shannon, Ireland; Reykjavik, Iceland; and Gander, Newfoundland. The airplane was a four-engine, piston/propeller plane; I believe it was a DC-6. By this time, jet airliners were in near universal use commercially. But the *Experiment* was a low budget organization and Icelandic Airways with its old airplanes was by far the cheapest way to cross the Atlantic. The flight was a rough, bone-jarring reminder of why jets had instantly taken over from piston engine airplanes.

These few short weeks were to have a profound effect on me. I had been told all my life that the USA was the greatest country in the world and that it was a privilege to live there. But clearly, I could enjoy living in another country.

Historical remarks

As I first left for California, major US bombing of North Vietnam was well under way and American ground troops were conducting their first combat operations in the country. Protests at university campuses across the US were starting and would increase in frequency and intensity in subsequent years. By the next year, an unidentified serving officer in Vietnam remarked to a journalist: "If there is a God, and he is very kind to us, and given a million men and five years, and a miracle in making the South Vietnamese people like us, we stand an outside chance of a stalemate." It became common knowledge that US soldiers were demoralized, many taking drugs, and that incidents of intentionally killing superior officers were increasing dramatically. By the start of 1968, the war was so unpopular that the Secret Service refused to allow President Lyndon Johnson to appear in public at US universities, for fear of assassination. Shortly thereafter he informed the country he would not seek a second term as President. The idea to transition to the all-volunteer military, as a way to undermine anti-war activism, found its origin in this period, but it took until the end of 1972 for active conscription to end. A phase of gradual withdrawal of US soldiers began, and ended as the city of Saigon fell to the North Vietnamese in 1975.

Race riots and the civil rights movement convulsed the country. In the Watts neighborhood of Los Angeles, in mid-August 1965, resentment over discrimination by police, over poor schools, hospitals and other services, exploded in a week-long riot that claimed 34 lives, over 1000 wounded, and nearly 3500 arrests. Each year for the next five years, racial unrest and violence flared up across the country, and following the assassination of Dr. Martin Luther King in 1968, culminated in riots in a total of 125 cities. It was decidedly not a happy country.

Legislative steps at federal level banned discrimination based on race, color, religion or national origin in elections, employment and public accommodation. Immigration by non-Europeans was made easier. None of these steps passed Congress easily and none was accepted everywhere. Confrontation between law enforcement and citizen groups was daily fare for the press.

Some consolation in all the turmoil was provided by space exploration, in which the US managed a number of successes. Its Ranger program provided spectacular close-up images of the Moon. Both the Soviet Luna and US Surveyor missions made soft landings on the Moon and, together with the Venera missions to Venus and Mariner missions to Mars, heralded an exciting new era of planetary exploration. And of course, the Apollo-11 and -12 manned landings on, and sample returns from, the Moon brought worldwide acclaim. They were seen as proof that the USA still had what it takes to lead the world.

Chapter 6
Down under

The people are immensely likable — cheerful, extrovert, quick-witted, and unfailingly obliging. Their cities are safe and clean and nearly always built on water. They have a society that is prosperous, well ordered, and instinctively egalitarian. The food is excellent. The beer is cold. The sun nearly always shines. There is coffee on every corner. Life doesn't get much better than this.

– Bill Bryson, in *A Sunburnt Country*

As the plane climbed up and away from Los Angeles airport, I watched my country recede into the distance. I recall thinking I might not be returning. Mother had prophesied as much, exclaiming when told I would be doing graduate study in Australia, that I would certainly meet an Australian girl and never return to the States. It was a prophecy that almost came to pass.

In any case, first I wanted to see more of the world. My first stop on the way 'down under' would be Tokyo. One of the astronomers I had come to know while observing on Mt. Wilson was Keiichi Kodaira. He had since returned home after studying in Germany and completing a postdoc in California. He had invited me to

visit the Astronomy Department of the University of Tokyo and give a talk on the infrared astronomy being done at Caltech. After my talk, I met Takashi Tsuji, who led the world in the interpretation of the spectra of very cool stars, the kind that are bright at infrared wavelengths. Some of these stars were known to show absorption lines of the element Technetium in their spectra. Now, Technetium was the only radioactive element detected in stellar spectra at the time, and I was interested to see whether one could learn empirically about the evolutionary timescales of such stars by measuring its abundance in stars in different stages of evolution. Without such an absolute chronometer one had to rely on computer calculations of stellar evolution, and I suspected these could be wrong by fairly large factors. Tsuji was clear, unfortunately, that the state of the understanding of such very cool stellar atmospheres was not yet adequately advanced to be able to do so. I believe that remains the situation even today.

Afterward, Kodaira took me to his home, which was exceedingly tiny. He explained that housing in Tokyo was very expensive, also that it cost almost as much to purchase a parking place for his car, which was at quite some distance from his house. His German-born wife was most gracious, but I couldn't help but think she must have had trouble adapting, after having lived in Germany and California.

For Americans, the signal event with regard to relations with Japan had to be the dropping of the atomic bombs on the cities of Hiroshima and Nagasaki at the end of World War II. While one may argue about the ethics of the decision to do so, the US remains the only country ever to use these terrible weapons in anger, and had done so on largely civilian populations. I felt no responsibility personally, but could not help but be aware of the collective responsibility of my country and its so-

ciety. So following my stay in Tokyo, I took an internal flight to Hiroshima to visit the Peace Memorial Museum, which documents the effects of the bombing. It is a powerful monument and should be visited by all Americans.

Kodaira had helped me also to plan a visit to the Okayama Observatory on my way back to Tokyo. I took the train from Hiroshima and was met at the local station by Kyoji Nariai, a friendly and most solicitous host. Japanese astronomers had a 188-cm telescope by Grubb Parsons, just like the one I expected to be using at Mt. Stromlo. But what impressed me most at the Observatory was a spectrograph at their solar telescope. It employed a new kind of dispersive element to form the spectrum, a so-called échelle grating, which allows one to format the spectrum in two dimensions instead of one. Instead of requiring a long, linear detector to record the whole spectrum in a single integration, with the échelle grating one could use a small square one. I mention this because an échelle would figure prominently in my future dissertation research at Mt. Stromlo.

I caught a 'bullet train' from a station near the Observatory back to Tokyo. It was a revelation: so much easier and so much more comfortable than flying! Why didn't the US have these trains between its major population centers? In Tokyo, I touristed for a couple of days, just experiencing one of the world's great cities. People were generally friendly and welcoming. Kodaira's sister took me to her dress shop and helped me organize sightseeing. I experienced my first uni-sex toilets, which for a young man from the prudish American mid-west was quite a shock. While I couldn't say I actually enjoyed the raw fish of the cuisine, I certainly found palatable everything I tried. Finally, I went back to the university to talk to a group of astronomy students about research in infrared astronomy.

Then it was time to move on to Hong Kong, to meet the family of Henry Tye, my physics friend and social football colleague. The flight was an adventure, or at least the landing was. Hong Kong airport at the time was one of the most dangerous in the world. It had only one runway and on final approach, I looked out my window and could actually see right into the living rooms of apartment houses as we threaded between the buildings!

I had written to the Tye's earlier, so they were expecting me. I made my way to their flat and knocked on the door. I was greeted politely, then asked to write my signature; they wanted to compare it to the one on my letter, to prove I wasn't an impostor. Thereafter I was received in a most friendly and hospitable manner and invited to stay with them in their flat. Indeed, they showed me around Hong Kong for 6 whole days, my not having yet learned – as the Dutch say – 'fish and visitors go off after three days'. They took me not only to tourist attractions but also to schools and universities, shopping areas and to restaurants. I especially enjoyed the dinners, where we sat together around a circular table, helping ourselves to each kind of food as it came around on a 'Lazy Susan'. I am sure the Tye family was amused watching me struggle with chopsticks. Having practiced in Japan, I could more or less manage, with only the particularly slippery or tiny bits of food defeating me (peanuts were the worst). The whole family took me to the airport on the evening of the 26th of February for my flight to Australia.

That flight went first to Darwin, where we sat on the tarmac for a long while. A quarantine official finally came on board and walked up and down the aisles spraying the plane against any foreign insects. All such officials wore white dress shorts and knee socks, which looked mildly ridiculous to me. At home, shorts were only informal, holiday garb, and never sparkling white and

neatly pressed. I would find pretty much every male in Australia wore such dress gear, and after a while I did too. In future years, after air conditioning had put in an appearance, the custom waned, and today one mostly finds it only in the northern tropical regions.

I gathered from other passengers that all kinds of things, including certain specific books and especially any girly magazines were forbidden. As I approached customs, they were indeed going thoroughly through everyone's luggage. When asked what I had to declare, I said a transistor radio, which I understood was illegal unless licensed by the Australian government. When asked what I would be doing in Australia, I said I would be studying astronomy. My customs man began then to wax lyrical about how bright the stars were where he had grown up in Western Australia. He then proceeded to pass me through without further inspection. I have since had similar experiences with customs and immigration officials in many countries. There is something about astronomy that is both fascinating and unthreatening to many people.

On to Sydney and finally the country's capital city, Canberra, which from the air looked very much a country town. It would be home for the next four years.

New arrivals were housed at the Australian National University's University House. This institution was not located on Mt. Stromlo, but on the main ANU campus in town. It was to a degree patterned after the residential colleges at Cambridge and Oxford: High Table at dinner in a large hall with a high ceiling, a Master to run the show, and diverse faculty and scholars in residence. It tried to instill the academic values of the university and promote camaraderie.

I learned that graduate students at the university were called Research Scholars, and were paid very much a living wage. Most Scholars were away from home for the first time. Australians generally attended university

close by enough to live at home, so most new Scholars were experiencing a freedom not previously enjoyed. It was an adventure for nearly all. There was no serious hazing, but new arrivals from overseas, like me, would have their sack lunch orders intercepted and converted to Vegemite sandwiches. For any uninitiated reader, Vegemite is an acquired taste, a highly salty paste made of leftover brewer's yeast and spices. To the non-Australian palate it is foul – there is no other word for it – but Australian's all love the stuff.

I do note that this was before universities in Australia were paid for the number of students they taught, so there were not very many Research Scholars – only three were admitted my year at Mt. Stromlo, and one left after a year, making it two. This limited intake was, I think, also typical of the other parts of the university's graduate program. Given the limited number of jobs available in astronomy, I think it was an entirely reasonable number.

Harry Hyland had told me Canberra was spread out, rather on the Los Angeles model, whereby an automobile was not a luxury. Scholars working at Mt. Stromlo had the free use of an official government car to drive together to and from Mt. Stromlo each day, a distance of some 20 km from the city center and main University campus. Otherwise, owning a car did turn out to be a necessity. I had had a Volkswagen 'beetle' in Pasadena, which I sold just prior to leaving. The exchange rate to the Australian dollar turned out to be very favorable, and I could purchase a new beetle for what I received for my used one in California. Unfortunately, the transfer of funds was taking forever. After a week or two, I was amazed to discover that the campus branch of the Commonwealth Bank of Australia was happy to lend me the funds at a very reasonable interest, until my own funds managed to make it across the ocean. I had no collateral at all, and was astounded at this turn of events.

It never would have happened in the US. It made me a life-long fan of the Commonwealth Bank, even after it eventually was privatized.

In my new car I was able to explore Canberra, and also drive the 280 km to Sydney to collect my belongings when they arrived by ship. I discovered that, while the roads in Canberra were excellent, the main arterial highway from Canberra to Sydney was a narrow two-lane road, and the main road into Sydney just an ordinary city street, clogged with traffic. It brought back memories of driving to Marblehead from St. Louis in the 1950s.

I had been told by my California shipping company that my things would arrive on a certain date, and that I would be notified by a still-to-be-determined Australian company as to when and where I might collect them. After some weeks with no notice, I telephoned California – an expensive exercise – and got the name of the Australian shipping company. A phone call to them saw them brush me off. So I drove to Sydney and fronted up to the shipping company's office. While I was received courteously, they claimed to have no bill of lading for my things and to know nothing of the shipment. I pressed the matter, and finally I was passed on to an elderly gentleman in their back office, who politely agreed to look through his card box. In doing so, he discovered that my shipment had indeed arrived some time previously and was being held at a customs warehouse awaiting clearance. In this case, 'clearance' meant the payment of import duties and taxes, which I had not been told about, but which I duly paid so I could free up my belongings and return home with them. This was my first experience with friendly people working in a demonstrably dysfunctional business environment.

It quickly became evident that there was very little to do by way of entertainment in Canberra. The city may have been the capital of the country, but except for

the very occasional play or concert, entertainment seemed to consist either of 'question time' at Parliament or evenings together with friends and colleagues. Question time could be raucously delightful, as politics in Australia is different from politics elsewhere: 'Does the member for [*somewhere*] know who his father is?' would not be unheard of in Australian parliaments. Otherwise, evenings and weekends at University House could be counted on to include getting together for drinks in someone's room or a party at a colleague's house off-campus.

The Mt. Stromlo Observatory itself was located on a rocky hill some 200 m above the general level of Canberra and about a 20 minute car ride outside the city. It is called a Mount, but like most all 'mountains' in Australia the term 'hill' better describes its nature. Indeed, Australia is not only the driest continent but also the flattest, its average elevation above sea level being 325 meters and its highest elevation only 1500 meters.

The Stromlo hill was covered with a dense pine forest that prevented good views of the surrounding countryside. But this forest also helped minimize the glare from the city lights of Canberra as well as prevent the rocky ground from getting so hot during the day that it would take all night to cool off and thereby blur stellar images seen through the telescopes. Even so, the city lights were bright enough that astronomy requiring dark skies had for some time not been possible, and was now done at Stromlo's outstation at Siding Spring Mountain, some 700 km to the north. The skies and the several telescopes at Mt. Stromlo itself, however, would prove adequate for the research I would be doing.

When I first showed up at the Observatory, I was received in a friendly manner, both by Olin Eggen, the Director, and by Alex Rodgers, who was responsible for Research Scholars. I was given an office to be shared with another starting student; he never made much use

of it and left soon after my arrival, so I ended up with my own office, where I could work undisturbed. The Stromlo library was excellent, with the essential literature and specialized manuscripts going back many decades. I was in heaven.

I had a general idea of the research I wanted to do. It followed from what I had learned in the nuclear astrophysics course at Caltech. I wanted to explore the evolution of the abundances of the chemical elements in our Milky Way Galaxy. It was believed that only H and He came from the Big Bang creation event, while all the heavier elements have been formed by nuclear reactions inside stars. Indeed, the relative abundances in the solar system correlated nicely with nuclear reaction cross-sections, and the physical conditions required for the relevant nuclear reactions could be found in the interiors of one or another sort of star.

Now, stars form as condensations of interstellar gas in the Galaxy. At the ends of their lives, when their nuclear fuel is used up, many die by exploding and returning much of the processed gas back into the interstellar medium. So clues to the history of the Galaxy should be written in the evolution of the composition of the interstellar gas over cosmic time. To observe abundances in the interstellar gas at different epochs, one could make use of two ideas from stellar evolution theory. First, stars like the Sun live longer than the age of the Galaxy, so once formed they remain available to be observed now. Second, they do not mix their surface material at any time into their interiors, where the nuclear reactions occur, at least until just before they die. Hence the observation of surface abundances in such stars should also give the composition of the gas from which the stars formed, and observation of such stars as a function of their ages should give clues to the cumulative history of element production in the Galaxy.

It was a long sequence of assumptions, but available observations, albeit at the time very limited, seemed to support the general scenario. Indeed, the oldest stars, thought to be those distributed spherically in a halo surrounding the disk of the Galaxy, are observed to have much lower average abundances of heavy elements (those heavier than H and He) than do the much younger stars in the disk. This was taken as evidence that the oldest stars show abundances closer to primordial than do younger stars. However, there was very little evidence that different chemical elements showed any relative abundance variation among halo or disk stars: The mean abundances might vary greatly, but the element-to-element relative abundances did not, at least insofar as observations could determine.

My contribution would be to study carefully the abundances of two elements built up by very different nuclear processes. I chose Europium, a rare earth element for which the nuclear physics plainly indicated it was mostly formed during explosions such as occur at the ends of the lives of short-lived stars; and Barium, an element built up very slowly during the normal course of the lives of long-lived stars. My hypothesis was that the different nuclear reactions, requiring very different environmental conditions, occurring in different kinds of stars over very differing time scales, would offer a good chance of showing relative abundance evolution over the lifetime of the Galaxy. All I had to do was observe their relative abundances in stars of different ages. This turned out not to be so easy.

To measure the lines of Eu and Ba, which are weak, I would have to use the high-resolution spectrograph at the Mt. Stromlo 74-inch telescope. High resolution would allow the lines to be separated cleanly from nearby stronger lines, but the light signal per resolution element would then be very weak. I would have to use

an image intensifier, which fortunately had just become available in the year or two before I arrived.

As there were no lecture courses to establish a hierarchy between academic staff and Scholars at Mt. Stromlo, interaction occurred in a very informal manner. We all sat together at morning tea (a ritual at the Observatory at which attendance was mandatory), and Scholars were treated almost as staff in assigning telescope time. Indeed, Alex Rodgers thought my project a good one, and helped me gain early access to the telescope for trial observations.

I was very excited that the project could get started and that I could learn to use the telescope and its spectrograph right away. The first observations, however, rained on my parade: the available spectral resolution turned out not to be high enough – the lines were smeared out and unable to be measured with sufficient accuracy. I was dismayed and not a little depressed, and I began to cast about for other projects for my PhD research.

Then, Mike Bessell, a Stromlo graduate recently returned from a postdoc at Yerkes Observatory in Wisconsin, came to the rescue. One day at morning tea, he recalled that Theodore Dunham, the person who a decade previously had built the high resolution spectrograph at the 74-inch telescope, had left a test grating of a new sort that might be useful – an échelle grating, the result of a test run by George Harrison at the M.I.T. grating lab. After a short search, we found the thing in a desk drawer in the optics lab. I knew about échelles because I had been impressed by the one at the solar telescope in Japan. The parameters of the Dunham grating were close to ideal for my project. Dunham must have realized the future scientific need for such a grating, even though he never installed it in the 74-inch. The reason he did not do so certainly was that its operation was sufficiently unusual that the whole spectrograph

would have to be redesigned just for this one grating. The same applied to me, of course. To fit the échelle into the existing spectrograph room and optics, I would have to devise an appropriate optical layout that would leave most components in their places. Thus began a period in which I taught myself the essentials of optics and optical design.

When my design was ready for implementation, I discovered that I could not get my system built in the Observatory workshop. The shop was occupied building a low-resolution, photon-counting spectrum scanner for work on faint galaxies, and this work took precedence. And, unlike at Caltech, the workshop was unionized and I was not allowed to use the machines in the workshop myself.

I was, however, allowed access to woodworking machines. So I built my échelle system out of wood and scrap metal and optical bits found lying about – all except a specially made lens that fitted into the front of the image tube, which had to be fabricated by the optical workshop. Even though the system had to be re-installed for each observing run (aligned using a laser, which thank goodness had been invented ten years earlier), it performed as designed. I was initially concerned that the wooden structures would not be stable enough to yield high quality spectra, but it turned out they were. It was a clunky setup, but I was immensely proud of how well it all worked!

I wrote my first academic paper to describe the system, which in fact was one of the very first échelle systems ever used for nighttime astronomy. After I left Mt. Stromlo, the Observatory implemented a proper échelle system, in which the optics were supported by metal structures and able easily to be inserted and removed at short notice in the spectrograph.

While all this was happening, I had time for other things as well. The pressure to achieve was markedly

less than at Caltech. I decided I had in fact embarked on a new life, and to celebrate this fact I thought I would change my countenance – I would grow a beard. A beard would have the advantage of requiring less effort than shaving every day, and might even make me look more scholarly, if perhaps not actually distinguished. I have sported a beard ever since.

I had time to get to know Canberra and its people. I found Bill Bryson's later characterization correct in most respects. In particular, the weather was lovely year round, the Sun shone and most days the sky was a deep, dark blue. Indeed, the Sun seemed to shine more fiercely than in the northern hemisphere. Only the food and the coffee – my time being before the cultural effects of the wave of immigration from southern Europe had taken hold – were not up to Bill's standards. That is, the food and the coffee during my stay had their origins in the historically British cuisine of the first European settlers, and therefore were largely uninspired and undrinkable, respectively. At least the beer was cold, unlike English beer, and it came in large (750 ml) bottles. I never got used to drinking tea, even though I quickly learned that for connoisseurs it is absolutely essential to put the milk in first. (Personally, I have never been able to tell the difference.)

A few things came as real surprises. I found the bars in pubs to have separate drinking rooms for men and for women. The women's side was called the lounge and was fitted out more or less like a café. The men's area had tiles up the walls and sawdust on the floor, and at the end of the trading day the whole room was hosed out with a garden hose. When I went with friends to a pub, it was socially required for each person to 'shout' all the others of the party at least once (that is, buy at least one round of drinks). I learned that I should volunteer my shout as early as possible, or I would have a hard

time making it home; I became known as a 'two pot screamer'.

Drinking was clearly a problem in Australia, and the measures in place to minimize drunkenness were characterized by their unintended consequences. First and foremost, to ensure that men would go home for dinner, the bars closed at 6 p.m. Most employees left work at 5 p.m., and would then drink as much and as quickly as they could until closing time; the consequence was a culture of swilling alcohol, which endures to this day.

Second, on Sundays the bars in pubs were closed to locals but open to *bona fide* travelers, whereby anyone more than 40 km from home could be considered a *bona fide* traveler. In Canberra on Sundays, people would drive to the pub in Collector, a tiny hamlet 45 km away on a windy, two-lane road, enjoy their drink, and then at closing time drive back to Canberra. It made Sunday travel on that road around closing time a seriously risky business.

I joined the ANU football (soccer) team, playing left full-back. Although more than a social club, the level of play was about the same as at Caltech. My partner at right full-back hailed from Liverpool in the UK and had a very strong accent; I don't think I understood a word the fellow said in two years of playing together. Luckily, during matches a loud grunt or shout would generally do to convey meaning. Several other players were also British and would occasionally astonish. One brought his 6-month old son to matches, because his wife had to work on match days. To ensure the tot did not disturb play, his infant's bottle was filled with beer. I assume it was diluted, but in any case the kid always went right to sleep and never caused any trouble.

I took up flying lessons with the local glider club, this being much cheaper than lessons with powered airplanes. The club was full of friendly and knowledgeable

people who enthusiastically received all potential pupils. On my first flight I was surprised to find that sailplanes are anything but quiet. They make a loud whooshing sound as they move through the air and their airframes creak and groan worryingly with every turn. The club's facility was located in a farmer's field. Launches were performed by connecting a long wire to the nose of the plane, and then winding it up at speed onto the wheel hub of a converted pickup truck located on brick blocks almost a kilometer away. The wire showed evidence of many breaks, and part of the early flying lessons focused on how to react should it break again during launch. The launches were in any case an adrenaline rush, first as the plane hurtled down the field and soared steeply up. Then, when it was judged that the altitude was about 800 feet, the wire would have to be detached so it could parachute calmly back to Earth. Of course, if you misjudged the moment to detach, you would either not have enough altitude to reach a nearby rising thermal of air, and would have to circle immediately and land, or you ran the risk of actually breaking off the wings.

After six sessions in a dual-seated plane together with an instructor, I was told I was ready to solo. I had indeed mastered the launch, the detachment, the location and exploitation of thermals to gain altitude, as well as the final approach and landing. My only problem was, in three of my six sessions, when it came time to land I had been unable to locate the correct farmer's field! In each case, I had to have it pointed out to me by the instructor. At 1000 ft altitude, there seemed to be many fields with machinery sheds on them, and as I looked down they all looked the same to me. While flying I clearly concentrated on finding and staying in thermals and kept losing track of where I was. If you lost your thermal and sank below 1100 feet, or if your allotted flying time was up, you needed to prepare to

land. You only got one shot at landing, of course, so you really needed to know which was the right field.

I reckoned I had a 50:50 chance of making a mistake and either having to land on a wrong field, or not quite making it back to the correct field, damaging the plane and possibly killing myself in the process. I concluded it was not worth the risk and decided to abandon the whole enterprise. Sadly, six months later, the young wife of a club member, who had been taking lessons at the same time as I did, and had expressed similar misgivings to me, crashed and killed herself. I may have been a gutless wonder, but I still think I made the right decision.

The Director at Mt. Stromlo, Olin Eggen, owned a elderly green and white Austin-Healey sports car. Being of British manufacture it could be temperamental, especially if not having been driven for a week or so. When Eggen went away observing, he would ask Garth Illingworth, a Scholar a year ahead of me, or me to take it out for a spin every couple of days. We alternated burning up and down the mountain in the thing, and I enjoyed every minute of the task. There is something about sports cars of that era that is immensely satisfying, and even now I still dream of someday owning one.

Some four months after my arrival in Canberra, in June 1970, a colleague at University House, one Grahame Smith, a Research Scholar in Physics, invited me to an off-campus party. It took place on a lovely Sunday morning at a house in a nearby suburb, shared by five young ladies. The latter had all come to Canberra to take up jobs in the Federal public service. It turned out to be a surprise party, at which Grahame announced his engagement to Ann Chester; the two were to become fast friends for the rest of my life.

The party introduced me to another side of Canberra – the young, well-educated elite of the public service. The banter was incessant, jokes and puns flying

back and forth with abandon. They clearly enjoyed each other's company immensely. The culinary fare was pancakes, the batter for which was mixed in large quantities in buckets, and the pancakes were flipped while the flippers tried to perform Cossack-style dancing; needless to say, a good many pancakes ended up on the floor. To drink there was a cocktail – brandy-alexander to be precise, a concoction of brandy, crème de cacao and cream – that also was prepared in quantity and which kept flowing, with the expected and presumably desired effect on the participants.

One of the young ladies flirted with me. She was introduced as Phillipa Newton from Queensland. She had a degree in history and had come to Canberra as a high-flying trainee administrator in the public service. Things American seemed to interest her, if not to emulate then certainly to poke fun at. A buxom girl with a huge smile and engaging manner, I was smitten.

It took a week or two to muster the courage to ask her out on a date, but she accepted for the 4th of July, 1970. We started going to dinner together at local restaurants, and then to visiting friends socially together, these being the most common diversions in Canberra. Indeed, Canberra then has been the only place we have lived where it was common for friends to drop around unannounced to spend unplanned time together just talking and enjoying each other's company.

Shortly thereafter, Phillipa decided the public service was not for her after all, and she took on a Masters degree course in Sociology at the ANU. This had the great advantage that she then qualified for an individual flat in Graduate House, a newly built set of self-contained units, in which we could start sleeping together. We were very careful not to have this activity discovered by her parents, as they would definitely not have approved; in hindsight this probably made our early intimacy all the more exciting. The dangers were that

Mrs. Newton might telephone and get me on the line, or Mr. Newton might show up in Canberra unexpectedly on business, which he did do occasionally.

When Phillipa finally took me to Brisbane to meet her parents, they were hesitant if not exactly hostile. They were particularly concerned she might not want to finish her degree in Sociology. Her aunt commented that during the war it had been learned that "Americans are great as lovers, but they burn out fast as husbands". But ultimately, of course, when it became clear that the relationship was serious, I became accepted warmly by the family.

It was while spending time at Graduate House that we got to know the Illingworths, Garth and Wendy. A year ahead of me at Stromlo, Garth was working in a different research area, and although his office was next to mine and we cooperated on exercising Eggen's sports car, we had previously had limited contact at the Observatory. Around Graduate House he was known as 'the legs' because he seemed to spend most of his time under his car, an aging Rover, with only his legs poking out. This was a most interesting car, as the trunk (or boot, as the Australians call it) was completely full of tools and spare parts; any other items such as suitcases had to be put in the back seat or on the roof. He and Wendy traveled several times per year back to visit their families near Perth in Western Australia, a distance of almost 4000 km. Much of that distance was a gravel highway at the time, with large distances between service stations and little chance of roadside help should things go wrong. As a consequence, Garth had become an expert mechanic and enjoyed spending his Sundays keeping his Rover in top condition. As well as having expertise in the maintenance of autos, Garth was an excellent driver who enjoyed speed and pushing the limits of safe driving. I know this because he generally drove the Scholars' government car to Stromlo in the morning, and would

regularly make the ride an exhilarating start to the day. We became good friends with both Garth and Wendy, and have kept contact throughout our careers.

At the end of about a year together, Phillipa and I decided to set a date to get married: 30 December 1971. The ceremony would take place in Brisbane, at a small Anglican church not far from the Newton family home, and my family would make the journey from the States. This suited us both, because it is customary in Australia for the bride's parents to do the heavy lifting, and so Phillipa and I could leave the arrangements and costs mostly to them. Indeed, Phillipa only traveled to Brisbane ten days before the wedding and I showed up with my parents, sister Nadine and brother Eugene only three days before.

Our wedding ceremony was conventional, with Phillipa's sister Helen as bridesmaid and my brother Eugene as best man. The only deviation to the standard ceremony of the time was Phillipa's desire to leave out the bit whereby the bride promises to obey her husband. The part where the groom endows the bride with all his worldly wealth she found quite acceptable, however, and so it was left in.

I have little recollection of the ceremony itself but for two vivid images. It was a typical Queensland summer's day, swelteringly hot and humid. As her father walked Phillipa down the aisle toward the altar and me, she was lovely, composed and completely cool, while he perspired profusely and had a large drop of sweat hanging off the tip of his nose. I was amazed at how large a drop it was and stared, waiting for it to drop off, which it did just as they arrived at the altar. The second image is of the Newtons' next-door neighbor, doing his best to disturb the proceedings by walking around the altar making a video of the event with a fancy new camera. Thankfully, the priest took this in his stride and in the end everyone seemed to enjoy how it all went. After-

ward, the congregation retired to a reception at a hotel some distance away, and suffered the requisite speeches and small talk. At the appointed time, Phillipa and I departed with much fanfare, although with family from the States visiting, we did not head off on a honeymoon right away.

Instead, we entertained my family and I traveled with them to see some more of the country. After they departed for home, Phillipa and I did attempt a honeymoon, but this was not a great success. We arranged to stay at the beach house of an acquaintance of Phillipa's, on the south coast not far from Canberra. We both came down with the flu just as we arrived, and felt miserable. What's more, it started raining heavily, spoiling any use of the beach. But the rain did cause a colony of huntsman spiders living under the house – spiders as big as one's hand – to want to come inside out of the wet; they waited outside and would try to run inside every time we opened the front door. For two days we sniffled and read and listened on the radio to the cricket, and then gave it up for a bad show and drove home to Canberra.

We looked around Canberra for a house in which to start our married life. We found one with three small bedrooms at 5 Grant Crescent in Griffith, one of the most sought after suburbs of the city. At $20 a week, even we could afford the rent, although of course there was a reason for it being so inexpensive: heating was a single combustion stove in the living room, and hot water was provided by a combustion stove outside at the rear. At least the combustion cooking stove in the kitchen had been replaced with an electric one. But the house had a lovely back garden and was a five-minute walk from a neighborhood shopping center. Except on cold winter mornings, it was pretty much idyllic.

We decided we needed a dog. Phillipa had grown up with a beagle, while as a child I had had a dachshund. We compromised with a basset hound, which we

named Bloopy. He was a dear thing, who had no difficulty sleeping all day when we were away at work. On the weekends we took Bloopy pinecone hunting in the Stromlo pine forest, to gather kindling for our combustion stoves. He was hopeless at chasing the kangaroos there; he could smell them and hear them, but got confused when he started after them and would quickly give up. He was also teased mercilessly by the tame cockatoo who lived across the street on Grant Crescent. The bird would hang upside down on a low branch of a tree in the front yard, and when the dog would run at him, would swing up out of reach and screech with laughter. Sadly, when we left for a job in the USA, we decided Bloopy would have to be left behind. Happily for him, we found a nice, rural home for him with a friendly lady in Sutton, a small village just outside Canberra.

At Grant Crescent we planted strawberries, pumpkin, beans, sweet corn and raspberries in the back garden and learned to harvest them while avoiding the poisonous red-back spiders. We even learned to value and protect the huntsman spiders who shared the house with us. Although they are huge and hairy and scary, they had one overriding attraction. Canberra in those days suffered from something of a plague of flies. This had to do with the introduced livestock in the surrounding countryside and the absence of native dung beetles capable of processing their manure. In any case, the house would fill up with flies during the day. Then in the evening, the spiders would come out and by morning, no more flies! Only big, fat, happy spiders.

Meanwhile, my research at Mt. Stromlo proceeded slowly. I had managed to define a sample of stars that both were bright enough that high resolution échelle spectra could be recorded with the 74-inch telescope, and were of a wide variety of ages. At the same time they had very similar other parameters to the Sun, thereby allowing differential measurements without

having to model the stellar atmospheres in detail. A doubly differential measurement could be made by using the lines of ionized Barium at 401.3066 nanometers, and of ionized Europium at 401.2973 nanometers, which are close to each other in wavelength, are of similar strengths and are formed in the same atmospheric layers of the stars. It was a good sample. The only problem I was having was with the weather. Over the space of two and a half years, I was granted 33 nights on the 74-inch for the work, but the weather was clear enough to observe on only 11 of those nights. In the end, I did manage to obtain high quality data on 18 stars.

Now, it is important to note here that digital detectors were not widely available at the time. While I had the use of an early image intensifier, which made the whole project possible, the spectra were actually still recorded on photographic plates. These not only had to be processed with messy, wet chemicals in complete darkness, but they then had to be scanned with a microdensitometer. Normally, output from the latter was simply onto chart recorder paper, but I needed to transform the non-linear photographic readings onto a linear flux scale. Luckily, the Observatory was willing to purchase a punched paper tape unit especially for me, which I could combine with an existing electronic digitizer to output my data in digital form. These paper tapes could then be transferred to the only computer the Observatory had, an IBM 1620. The paper tapes were read in and the densitometer readings converted into linear fluxes and finally output again onto a chart recorder. In the process I accumulated quite a large number of rolls of recorder paper.

I experimented with measuring the line strengths digitally with the computer, but concluded it would be quicker to do the measurements by hand with a mm-scale ruler using the linearized chart recorder tracings. The IBM 1620 computer was amazingly slow and the

prospect of fitting theoretical line profiles to noisy data was not a realistic alternative. For example, when debugging new programs, you could place a transistor radio on top of the CPU cabinet and listen to the squeaks and blurps it made as your program went through each step and loop. I got good at recognizing the sounds of multiplications, data transfers etc, and this made it easy to tell when things went wrong in the program. Even making pretty graphs of the data was a non-starter with the available computer hardware; all publication quality graphics still had to be done by a draughtsman in the drawing office.

I concluded it would take a month or two of monotonous work to complete the measurements manually. As my observations proceeded, I was not looking forward to the task.

As perhaps the foremost southern hemisphere observatory at the time, Mt. Stromlo regularly hosted visits by foreign astronomers. In early 1971, Prof. D.Ya. Martinov visited from the Sternberg Astronomical Institute in Moscow. He was Director there and came on an official exchange program between Australia and the Soviet Union. He said that Russians regularly visited Australia on the program, but Australians seldom came to Moscow. I expressed interest and he urged me to apply. Evidently, his institute was so keen for visitors, it would not even be necessary to speak Russian! A semester in Moscow would be an exciting diversion, while I plowed through the task of measuring my spectra by hand. And if Phillipa and I married, we could have the adventure together. I applied and was accepted. Our sojourn in the Soviet Union is a tale apart, however, and requires a chapter of its own. We went at the start of winter 1972, and we returned in February 1973.

On our return to Canberra, I was ready to start writing up my dissertation research. I had found no detectable variation in the Europium to Barium ratio in

stars having a wide range of ages, essentially over the whole age of the Galaxy, and only a small deficiency of Barium in the most extreme halo star in the sample. It was a curious result, which makes one wonder how heavy element synthesis and subsequent enrichment of the Galaxy's interstellar gas could possibly have been an on-going process over the whole lifetime of the system. Actually, I think the result is still a conundrum.

Alex Rodgers was pleased with my work and offered me a temporary research fellowship following submission of my dissertation, with at least good hope that it might later on evolve into a permanent position at the Observatory.

I was convinced I could do the writing in about three months, but of course it took six. As an aside, there were no word processors in 1973. Dissertations at the ANU had to be typed by hand and each page had to be perfect – no erasures or 'white-out' correction fluid could be tolerated. I was extremely fortunate that one of our secretaries was willing to do the typing (for a fee). She had one of the then new IBM Selectric typewriters, the ones with the little ball and with the capability to re-type using a white ribbon, leaving no trace of a mistake. She could even read my handwriting; I owe her a great debt. The thesis was entitled *Observational Aspects of Nucleosynthesis* and was accepted right away by the University. I could prepare for my thesis defense.

As I began to prepare, the Director of the Steward Observatory at the University of Arizona in Tucson, one Peter Strittmatter, visited. Steward was building an échelle spectrograph for their 90-inch telescope on Kitt Peak mountain, and was looking for a postdoctoral candidate to finish its construction, bring it into operation, and then of course do some important research with it. He liked what he heard about me and offered me the inaugural Bart Bok Fellowship at Steward. I was flattered. When I discussed it with Phillipa, she jumped at

the chance to spend time in the other great superpower, the USA. There were at the time practically no other candidates who had built and worked with échelle-based instruments, so my application was processed very rapidly and the job formally offered and accepted. But of course, I still had to defend my dissertation.

Thesis defense in those days was typically 3 hours long and conducted orally. The topics covered could include anything in all of physics and astronomy; that is, it was a test of general knowledge as well as of the specific topic of the dissertation. The ANU insisted furthermore that PhD examinations be conducted by international (non-ANU) experts in the field, and they most often took place overseas. This policy both assured that the evaluation could be at the highest possible level, to which ANU aspired generally in research, and also that the candidate would become known to the principal opinion makers in the relevant research area. In my case, the panel was Willie Fowler, nuclear physicist at Caltech, Nobel Prize winner and a founder of the field of stellar nucleosynthesis; Wal Sargent, senior astronomer at Caltech with a very broad range of interests; and Bernard Pagel, foremost English expert in the determination of chemical abundances in stars. From ANU's point of view it was an ideal committee; from my point of view it was terrifying.

The defense took place in a small lecture theatre in the Physics Department at Caltech, as Phillipa and I were travelling on our way to Tucson and my new job in Arizona. Pagel did not attend but sent a long list of questions. I stood in front of Fowler and Sargent, but otherwise I have no recollection at all of what questions were put to me. Evidently, I performed adequately; I only had to wait 15 minutes after being sent out of the room for Fowler and Sargent to emerge and let me know I had passed.

And so ended one of the happiest and most stimulating periods of my life

Historical remarks

As a consequence of the events of World War II, Australians became worried about invasion from the north – the 'yellow peril' in the vernacular. The watchword became 'populate or perish' and an aggressive program of assisted immigration, principally from Britain but also including refugees from Eastern Europe, was begun. The single year of greatest immigration was 1970, the year I came to Canberra. Even so, there were only very limited effects noticeable of this immigration while I was in Canberra. Culturally, the country was still focused on the 'Mother country', with almost as much news media attention devoted to events in the UK as to ones in Australia. The export economy was dominated by primary production – agriculture and mining. Import tariffs were high and foreign products were mostly from the UK. The politics were overwhelmingly conservative. Attitudes to the indigenous population remained appallingly racist. Censorship was extreme by American standards, with strict libel laws and even fairly innocuous magazines like *Playboy* banned. Sport seemed all-important, with the four kinds of football as well as cricket, tennis, swimming, and horse racing occupying large segments of the daily news.

As the 1970s gathered momentum, much in this stable, complacent society began to change. The initial signs of American culture were beginning to appear: the first Kentucky Fried Chicken outlet appeared in Sydney in 1968, the first McDonald's hamburgers in 1971, but Hollywood already dominated the cinema scene. The Labor Party under Gough Whitlam came to power in 1972 and began to implement real policy change. Military conscription was abolished, as was the death penalty. Australian troops were pulled out of Vietnam, and cordial relations with China were initiated. University tuition fees were abolished and funding for schools was increased. Finance was provided for highways linking the capital cities of the Australian states, and for standard gauge railway tracks between the states. Limits were placed on the amount of foreign, mostly American, entertainment that could be broadcast, and subsidies for Australian film production became available. Many Australians of British origin felt betrayed when the UK joined the European Economic Community in 1973; Australia's privileged access to British markets evaporated overnight, and the country scrambled to find new markets in Asia. The 'White Australia policy' was also abandoned in 1973, and it became possible for a wave of Asian immigration to begin. In the late 1960s, Australia had replaced its pound-shilling-pence currency with the decimal dollar, which was pegged to the US dollar. During the 1970s, the imperial system of units of weights and measures was abandoned and the country converted to the metric system. Many Asian and African countries drive on the left, however, and Australia has to this day retained this convention.

Chapter 7
Another world

Anyone who does not regret the passing of the Soviet Union has no heart. Anyone who wants it back has no brain.

– Vladimir Putin

During his visit to the ANU in 1971, Professor D. Ya. Martinov encouraged me to apply for an exchange studentship to Moscow. He promised there would be no problems, even though I did not speak Russian fluently. He would know, he said, because as Director of the Sternberg Astronomical Institute of the Moscow State University (MSU), he would be the one signing off on my application.

For both Phillipa and me, a sojourn in the Soviet Union would be an adventure. While not exactly closed to foreign tourists, travel in the Soviet Union was strictly circumscribed. Soviet citizens required passports to travel internally, and could only rarely venture abroad, and only then with formal approval of the government. On the other hand, the founding principles of Soviet socialism were, and still are, intellectually attractive. We were curious about what life would be like in such a country, not withstanding the virulent anti-communism

practiced by the political elite in both Australia and the USA.

I applied and my application was indeed successful. Phillipa and I made plans, including hurried language lessons, to begin a semester in Moscow from August 1972. My host and supervisor there would be Solomon Borisovich Pikel'ner, a professor at the Sternberg Institute and a noted expert on the physics of stellar atmospheres and of the interstellar medium in the Galaxy.

We quickly discovered that Soviet bureaucracy was rightly famous for its dysfunction. Our travel visas were delayed past our agreed starting date. When they finally did arrive, our six-month sojourn had shortened to four. We decided to board the next available flight. But these were the days of bank cheques, which took a week or more to process, so we had to pay in cash. The largest denomination I could get from our bank in Canberra on short notice was $20, and so with a shopping bag full of bank notes, I managed to acquire the tickets and could send a telegram to Professor Martinov with our arrival times. We enquired about obtaining rubles to see us through our first few days in Moscow, but rubles were not convertible at the time and could not readily be obtained outside the Soviet Union. So we took US dollar travelers' cheques and hoped for the best.

The trip to Moscow went via Bangkok, where we picked up an Aeroflot flight, our first direct contact with life in the Soviet Union. The cabin was without color or decoration. The attendants were Slavs – frumpy, short and overweight. The food was just this side of inedible – I had an apple with a dried, dead worm in it. At least the pilot had a Scandinavian countenance. I believe the plane itself was an Ilyushin Il-62, an aircraft of the Boeing 707 and DC-8 generation.

We arrived at Vnukovo Airport outside Moscow in the late afternoon, tired and apprehensive. This was

strange, as Vnukovo was the domestic airport serving Moscow. So of course there were no immigration and customs officials present to greet us. When an immigration lady finally did show up after a long wait, she took our particulars on a blank sheet of paper rather than on a prepared form. Why Vnukovo, instead of one of the two international airports, we never discovered.

Except for the long wait, we sailed through immigration and customs with ease. The formalities were less intrusive than those at Australian and American airports (even then, and much, much less than now, of course). And to our relief, Nicholai (Kolya) Bochkarev, one of Pikel'ner's graduate students, had discovered the arrival airport and was in the lobby waiting for us. He hailed a taxi and escorted us into Moscow.

The road went through long stretches of deserted birch tree forest. Moscow clearly did not know about urban sprawl. On arrival at the university, we were refused entry. The gate was guarded, as indeed was each floor of the main university building, by a *babushka* – being a 'grandma' of indeterminate age wearing a headscarf and keeping watch on comings and goings. She would not let us in because we had no pass. When asked where we needed to go to obtain a pass, she replied, "Inside, up on the admin floor, but it's closed now". We needed a pass to get in to obtain the pass, a perfect Catch-22. After some discussion, Kolya left us standing and went inside to see what he could do, some time later returning with a note that convinced the *babushka* to let us pass.

Our room was number 519 on the fifth floor of a wing of the main MSU building located on the Lenin Hills (now Sparrow Hills) at the edge of the city. Evidently, foreign students were all housed on the fourth and fifth floors of our wing. The building was one of the seven skyscrapers built by Stalin following World War II. It sported 36 floors and, from its inauguration in

1953 to 1990, was said to be the largest building in Europe. It accommodated classrooms, auditoria, cafés and restaurants, administrative offices, and student accommodation among other things. The student accommodation included interesting features such as central vacuum cleaner connections along each hallway, so cleaners only had to carry the hose. The electrical outlets were not Soviet/European standard 220v with round tined pins, but 110v and taking two-pronged American style plugs – presumably a leftover from the Lend-Lease program during World War II. Each room had a radio with only one station, the official government one. Most of the time, we would learn, the programming featured enthusiastic reports of various industries having met their mandated production targets.

Our suite, such as it was, had two small, 6-ft by 10-ft bed-study rooms located on opposite sides of a shared vestibule and bathroom. A Canadian from Edmonton lived in the bedroom-study opposite to ours. There was a table in our bed-study, but to our initial dismay only one bed, a single.

When we fronted up to the Foreign Student Administration the next day to get our passes, we were told that Phillipa had not been expected and would have to return right away to Australia. Luckily, we had help dealing with the situation. The leader of the American exchange student contingent happened also to be present and spoke fluent and assertive Russian. I know not what he said, but in the end, we got our passes and a second bed, although not a larger room. Two beds and the table were all that could be fit in our room, and the table, on which I would be reducing my data, could only be used by shifting it out into the vestibule.

Not only foreign students were housed on our floor, and we were informed by a Russian student that we were expected to take our turn every couple of weeks sweeping floors and answering the communal floor tele-

phone. In truth, my Russian was not up to the latter, and when I took my turn, I always answered by asking the caller to wait a moment, then saying that the particular student wasn't in and I didn't know when he or she would return. When asked to take a message, of course I agreed, but I never actually understood well enough to deliver any message. Indeed, colloquial Russian eluded us during our whole stay. On the other hand, there were so many things in Soviet life that didn't work properly, I don't suppose anyone took my non-performance too seriously. I certainly never got into any strife over it.

There was a communal kitchen that we learned to use. It had a gas stove and some pots, although refrigeration was done between the inner and outer windows of our bedroom, which remained just above freezing most of the time. Our floor's kitchen was often a very busy place around dinnertime. Its main feature, we were informed, was that one should always turn the gas burner on *before* setting a pot with food on the stove – otherwise there was a real danger a cockroach would run up and into the pot. Several weeks after our arrival, a notice did appear on the hall bulletin board: On such-and-such a day we were to leave our doors unlocked, so all rooms could be sprayed with poison against the cockroaches. Well, everyone complied except one poor American, who was not willing to leave his room unlocked and unsafe while he was away. His reward on his return in the late afternoon was an unbelievably huge number of cockroaches congregating in his room to avoid the poison present in all the other rooms.

We quickly made friends with the single other participant in the Australian exchange program, Julian Leslie. His Russian was even worse than ours, but he didn't seem to care. He quite happily blurted noises that must have been Russian to his thinking, but when accompanied by hand signals and other gestures, it was

amazing how far he got. He seemed not to take the difficulties and privations of daily student life seriously. We enjoyed his company immensely.

We made friends with the French contingent and with the Canadians. They were generally pleasant and interesting, although the French snickered in private that the Canadians from Montreal spoke 'like peasants'. Our roommate was from Edmonton and no matter how cold it got outside, he would always say it was not as cold as in Edmonton. He also almost never rugged up like the rest of us regularly did when venturing outside.

The American students were a curious lot. They complained about everything – how bad the food was, how difficult it was to gain access to the archives they had been promised to be able to consult, how hopeless the university bureaucracy was, and so on. They all spoke Russian fluently, very fluently, insofar as we could tell, just like the natives. Some dressed like Russians and were absent for days on end. They were convinced that there were listening devices in all the rooms, that all their conversations were recorded and that they were followed wherever they went. They even pointed out a truck that stopped outside the building late one morning, and told us it was there to collect the tapes from the previous day. Well, it may all have been true, but I imagined, if they didn't actually work for the CIA, they probably had been admitted to the American exchange program only if they agreed to do some spying. Their language and knowledge of the country seemed just too good for them to be simple university students.

The Sternberg Astronomical Institute, ostensibly where I was to work, was in a separate building a 15-minute walk from the main MSU building. My second day, I met Kolya there. He showed me around and introduced me to Professor Pikel'ner. I was surprised to find that there were so many staff that grad students had to work on tables in the hallways, except in their

last year when writing their dissertations. Even full professors had to share offices: Pikel'ner shared a small office with Iosif Shklovsky, a very famous theoretical astrophysicist who among other things had first explained the non-thermal radio emission from the Sun and from galaxies. My initial confrontation with Shklovsky occurred one day early in our stay, when I was looking for Pikel'ner. I knocked on the office door, looked in and found Shklovsky alone. I asked if Pikel'ner was in or when he would be in later. Shklovsky said he didn't know. Then he said, "Butcher, your Russian is like my English, terrible!"

I found the staff at Sternberg very friendly and willing to discuss their research with me. Kolya showed me the computer system, which was a Soviet machine, BESM-4 (BESM standing for Big Electronic Computing Machine – don't you just love the Soviet names for things!), of the IBM-360 generation. He programmed via punch cards in ALGOL, FORTRAN not being available. On-line storage was in the form of drums instead of disks. But in any case, Kolya was able to do pretty much everything he needed to do with the system.

Far and away, the highlight at the Institute was the weekly seminar. Students and staff filled the small auditorium to overflowing. While Soviet scientific instrumentation was generally not competitive with the technologies available at western observatories, Soviet theoretical prowess was often much superior. The top astrophysicists in Moscow at the time included Zeldovich, Shklovsky and Sunyaev. This trio would lead the seminar discussion of some physical phenomenon, often shouting at each other while jumping up onto the dais to make an argument. At some point, they would always call on one of their grad students or postdocs to explain some aspect of the theory being discussed. I am sure the latter dreaded being the center of attention, as any shortcoming would be quickly and mercilessly pointed

out. All in all, though I sometimes could barely follow the rapid argumentation, I understood enough to find these seminars exceedingly entertaining as well as being intellectually stimulating.

Among the astronomy students I met were two lovely young ladies of Asian appearance, who said they hailed from far outback Siberia. Evidently, young people from across the Union stood a good chance of gaining entry to MSU, if only they were smart enough. Women were in the minority among the students, but I was given to understand they felt they were not discriminated against.

Back at the dormitory, we did note, however, that some students had almost as much culture shock coming to Moscow as we were experiencing. For example, the public toilets in the main university building were of the western type, having sit-down toilet bowls and fold-down seats. Pretty much everywhere else we went in the country, however, squat toilets were the norm – a hole in the ground with a brick on each side for your feet; if you were lucky there was a handle to hold onto, but mostly not. Actually, we came to appreciate that this style of toilet had certain advantages, among which was their use in very cold weather, when your bottom would freeze (literally, as many toilets were in unheated outhouses) to a seat. Many of the sit-down toilets at the university had had their fold-down seats removed. And on weekends it was clear that people had tried to climb onto the bowls and squat, but slipped and then been unwilling to clean the resulting smear of feces around the bowl. Yuk!

Some events at the University were exciting and noteworthy. One evening in the auditorium we heard David Oistrakh, one of the pre-eminent violinists of the 20th century, in concert playing Khachaturian. We attended a speech by, and student greeting session with, Salvador Allende, the Marxist President of Chile, who

told us about the process of introducing socialism into his county (only nine months later he would be overthrown and assassinated in a CIA-sponsored coup). And we listened on our in-room radio to real-time commentary from the mission control room of the Soviet Lunakhod-2 robotic automobile as it maneuvered around on the surface of the Moon.

While I was puttering around Sternberg, talking to staff, attending lectures, and doing my data reduction back in the vestibule of our dormitory suite, Phillipa was busy exploring Moscow. She learned to use the metro and took trams to the ends of the city, exploring residential neighborhoods, markets, museums and shopping streets. Typically, I worked mornings and we went out together afternoons. While there were very few automobiles on the roads, we were impressed by the public transport, not only the famously beautiful metro stations, but also the fact that the trains came every 2 minutes, and buses and trams every 3 minutes during rush hours. Clearly, public transport worked well and moving around the city was not one of the difficulties of Soviet life.

People on the metro read books. We never saw so many people reading so voraciously, including many volumes translated from western authors. We discovered that books were very cheap and plentiful, if perhaps not of works by proscribed authors like Solzhenitsyn. Phonograph records were also very inexpensive and readily available. You were even allowed to listen to the records in the store for as long as you wanted, so even though we had no phonograph, we could sample wonderful classical and folk music recordings.

Many aspects of life in the Soviet system were particularly frustrating. A visit to many a museum or specialty store was met with locked doors and a sign saying 'Under Repair'. When we went out to eat at a fancy restaurant on the Arbat shopping street, the menu

was a dozen pages long and listed many interesting sounding dishes. But after being told three times that our choice was not available, we asked what was available? It seemed only three dishes were, and so we had to settle for *borscht* and *pelmeni*, which we could also get from time to time back at the university cafeteria. Needless to say, the restaurant was not overly crowded with customers. The nearby public market was huge, but the only meat we could purchase was either kilo-meat or half-kilo-meat. No telling what kind of meat it was, only that it was all that was available. Many of the neighborhood stores seemed either to sport largely empty shelves, or rows of shelves filled with only one item, typically tins of condensed milk or something similar. Logistics and supply chain management were manifestly not strong points of the Soviet system.

Being foreigners, we were lucky of course. We had travellers' cheques in dollars, so we could use the *beriozka* shops. These were stores stocking items unavailable to the general public, which could only be bought with foreign currency. We had a choice between filet mignon and tenderloin from these shops, or half-kilo meat full of bone and gristle from the public market.

Possessing foreign currency and a foreign passport also gave us priority in getting tickets to the Bolshoi and other cultural venues. We could simply front up to an Intourist office and pick up tickets. Neither of us had ever experienced such spectacular ballet and opera as we saw in Moscow. We would watch spellbound for what seemed like but a few minutes, when the performance would suddenly be over. The reputation of the Bolshoi and its artists was richly deserved.

In contrast, perhaps the most disturbing observation was of the occasional corpse lying frozen along the street. What exactly that meant about the Soviet system I still am not certain. All buildings were warmed and warm clothing seemed readily available. The official line

was that such things did not exist, as indeed, was the official line concerning prostitution and violent crime. Later on, I had good opportunity to consult doctors both in Moscow and in the countryside, and everywhere they seemed to provide good, if basic, medical service at no cost. I suppose the problem was people getting drunk, falling asleep and then freezing to death during the night. But there seemed always to be militia patrolling the streets, so why we would come across corpses is still a mystery.

More interesting things also happened when it got very cold. As the temperature declined, the fat content of the ice cream sold by street vendors increased. So even at twenty below, you saw ice cream cones being eaten by crowds along the street, and after trying one, I can vouch for them helping keep you warm. People began to look out for each other too. One day as I waited for a bus, a *babushka* came up to me and said my nose was freezing. She and her friends gathered around me, insisting that I bend over with my head between my legs and start rubbing my nose vigorously. What could I do but comply? When the bus arrived a minute or two later, I straightened up, they looked carefully at my nose, pronounced it saved, and we all got on the bus.

Not long after our arrival, brother Eugene's girlfriend, Susie Curtis, unexpectedly showed up. It turned out she was visiting her sister and brother-in-law, a Second Secretary in the diplomatic corps at the American embassy. Susie was a treat. She brazened her way into the university building without a pass, got us into the American embassy commissary strictly against the rules (so we could have a cheeseburger and coke, and buy some peanut butter – it's strange the things one misses!), and gave us a tour of the embassy complex. She invited us for dinner at her sister's, where we watched the evening TV news in Russian and heard that her brother-in-law's career ambition was to be appointed *chargé*

d'affaires to Mongolia. He had studied the Mongolian language and culture at university and hoped to put it to good use at some point. Unfortunately, junior diplomats generally get sent to all kinds of undesirable posts before landing where they actually would like to serve. We lost touch after we left Moscow, and I do not know if he ever achieved his ambition.

The other diplomatic contact we had, of course, was with the Australian embassy. One week, we and Julian were invited to drinks and midday dinner with the ambassador. We were craving good food at the time and looked forward with great anticipation to the meal. Over pre-dinner drinks, we met an Australian studying cinematography at the All-Union State Institute of Cinematography. He had been in Moscow for several years already and professed to being happy with both the Institute and life in general in Moscow. He said you get used to the dysfunctional aspects of the society and learn how to live with them.

Now, I had not eaten anything before arriving at the ambassador's. Drinks lasted quite some time and I became rather tipsy before we were invited to adjourn to the dining room for dinner. I watched carefully, through the haze of my tipsiness, the order in which the first two courses were served by the waiter, noting each time that I was the last to be served. So when the meat course came along, I cheerfully helped myself to what was left on the serving plate. But this time, the ambassador himself had not yet been served. I was most embarrassed. He, of course, made diplomatically light of my *faux pas* and the waiter scuttled back to the kitchen for an additional helping of meat. I resolved to be content with a single pre-dinner drink in future.

Kolya and his wife Zhenia invited us around to their flat for dinner one evening. This was a minor big deal, because social contact with westerners was frowned upon by the authorities and could lead to un-

wanted attention from the security forces. But we were keen to see how people of our age and educational level lived. We knew everyone in Moscow lived in high-rise buildings, but even so were surprised to find that Kolya and Zhenia lived together with their parents in a very small flat. The food was carefully prepared if no different from what we could get at the university. It was a stilted evening, but we were grateful for their willingness to receive us and to put up with our poor Russian.

We had no difficulties organizing day trips by train to various of the small, historically significant towns around Moscow – Zagorsk, Vladimir, Suzdal and the like. We also went to Leningrad and stayed in a student dormitory that had hot water for only an hour each day. But the Neva River was frozen and very beautiful, as were the Winter Palace, Hermitage, and Peter and Paul fortress. We resolved to return to this city one day in the summertime.

Back in Moscow, the Sternberg Institute helped us organize a trip to their observatory in the Crimea, to the Byurakan Observatory near Yerevan in Armenia, and to the Special Astrophysical Observatory near Zelenchukskaya in the Caucasus – all internationally well-known observatories.

We spent New Years at the Crimean Astrophysical Observatory, where the staff all lived on the mountain in the small town of Nauchny ('Science'). It was a lovely village, with a couple of stores and school. We did notice the absence of modern conveniences like washing machines, and people's laundry was hung outside to freeze dry in the sub-zero cold. For New Years Day, we wanted to fix a special dinner for ourselves. So we caught the bus to Simferopol, the nearest city of any size, some 25 km distant, and went shopping. We couldn't find any turkey, but we did come across chickens in the market. They had been delivered frozen into a large cube maybe a meter on a side. After you paid your

money for a chicken – you were only allowed one – a man would swing an axe to chop off a bird. You didn't always get a whole bird, of course, but at least they were more or less de-feathered. We also noticed that many vegetables were pickled, for preservation through the winter. We even saw large barrels of watermelons pickled and floating in bright purple brine.

Upon our return to Nauchny, we were told a group of Russian astronomers had just returned from the Soviet observatory in Chile and would be hosting a party, to which we were invited. We were warned that, because there was no limit on the importation of alcohol into the Soviet Union, several crates of Johnny Walker whiskey had been brought back, and we should expect some serious drinking. We were advised to eat several gobs of butter beforehand, which hopefully would line our stomachs and minimize the alcohol uptake. In the end, as foreign guests, we couldn't refuse toast after toast after toast. While the butter worked for me, Phillipa got sick and when the sky cleared after midnight, I left her, head in the toilet, and went off to the telescope to see how their instrumentation and observing protocols worked in practice.

Our trip involved Aeroflot flights in Ilyushin Il-18 turboprop planes, first from Moscow to Simferopol, then after our stay in the Crimea on to Yerevan and finally to Mineralnye Vody. In Yerevan we learned about the Armenian Orthodox religion and the massacre by the Turks in 1915. From Mineralnye Vody, we drove some 5 hours from the airport up into the mountains to visit the new Soviet 6-m optical telescope, the largest in the world at that time. It was having teething problems and the weather was terrible, so I didn't learn much, but it was interesting to see that the astronomers could and did ski from their dormitory to the telescope.

Remarkably, traveling by air within the Soviet Union was rather like traveling by Greyhound bus in

the USA or Australia. Tickets were not expensive, and as you fronted up with your ticket, you were ushered out onto the tarmac to a long line of airplanes. You wandered along them until the number on the plane matched the number on your ticket, and then you got on. No reserved seats or anything like that. And passengers brought all manner of belongings with them, again just like people did on long haul buses at home.

I started to develop a skin rash. In Nauchny, I went to the local clinic and was treated well, although I was given some salve that didn't help. When I got back to Moscow, I went to a clinic recommended by the university. The consulting physician was a large, middle-aged lady, who took one look and diagnosed vitamin B deficiency, which made sense given our diet. I took the prescription to a local pharmacist, to discover that the remedy was contained in several large, liquid-filled glass ampules, which I was to take back to the doctor to have injected in several sessions. Well, this was too much. I decided maybe the rash wasn't so bad after all.

Luckily, our stay was almost at an end. I had managed to get all my data reduced. We had had our fill of life in the Soviet Union and were eager to leave. In February 1973, we caught a flight to London. On our arrival, we were met by John Corrie, a fellow student and friend from Canberra, who had recently got a job in London. Last year, some 42 years later, he visited us in Canberra and recalled that we were like children in a candy store. We couldn't get over all the colors in London after the grey, grey, grey of the Soviet Union. Stores were filled with all sorts of goodies, and there was food from all over the world readily available. My rash went away within a few days. Then home to Canberra.

What is left behind from the sojourn? As Mr. Putin remarks, there were good things amid the dysfunction of Soviet society. But I would henceforth always measure life in different countries and cultures by com-

parison to life in Moscow in the early 1970s. So far, Moscow has always come off worst.

Chapter 8
In the desert

All truth passes through three stages. First, it is ridiculed. Second, it is violently opposed. Third, it is accepted as being self-evident.

– Arthur Schopenhauer

We arrived in Tucson in mid-summer and found an apartment within easy walking distance of the University of Arizona campus. Supermarkets and other shopping were a bit farther away, but air-conditioned busses ran along nearby streets. With the most important services and work close by, Phillipa decided we wouldn't need to buy a car. We would do our bit to promote sustainability.

Now, Arizona in summer is an experience apart. Yes, it has a dry heat, but it is hot enough to cook an egg on the footpath in a minute or two, and in the heat of the day, grabbing anything metal outside will burn your hand. Tucson is a city characterized not only by hot, dry, sunny weather for 6 months of the year, but also by its very considerable sprawl. I was skeptical about not needing an automobile.

I needn't have worried, because after a few weeks it became clear that the buses often ran late, and any ice cream or other frozen food would then not make it home before dribbling out of its packaging. We tried taxicabs, but their service turned out to be unreliable. A car could now be rationalized and we bought an early, inexpensive Subaru. As a concession to sustainability it had no air-conditioning. The steering wheel sometimes got so hot it couldn't be touched. But it was much better than no car.

Other aspects of life in Arizona were also irksome. Commercial advertising was intrusive and absolutely everywhere. Speedway Blvd, the main east-west artery of Tucson, was one long series of billboards and garish advertisements; in 1970, *Life* magazine had dubbed it the ugliest street in America. Much merchandise in the US is clearly wasteful and unnecessary; Phillipa had particular difficulty dealing with the excessively large range of choice in most stores. The semi-infinite varieties of breakfast cereal, for example, most being unhealthy and focused on children, were a particular irritation. We also decided to combat such waste by boycotting certain aisles of the supermarkets.

The lack of regard for sustainability was a puzzle in other ways as well. Clearly, the Sonoran desert was in its way both beautiful and fragile. But not only did people drive everywhere – pedestrian footpaths were hardly anywhere in evidence – and plaster irritating billboard advertisements across the landscape, but its citizens, mines and farms also squandered water with abandon. All water came from wells sunk deep down into an ancient underground aquifer, which was being drained dry at an alarming rate. One couldn't help but think there was here a future disaster in the making. That the political elite could not or would not deal with such an obvious problem of fundamental significance at-

tested to the reign of the cult of individualism over the need for occasional collectivist action.

The general lack of interest in the rest of the world was striking. When she decided to take courses at the University of Arizona, Phillipa was told that, as a foreigner, she would have to take an English language proficiency test. We were both dumbfounded to learn that the locals confused Austria and Australia, and if they knew they were different countries, they seemed not to know what language was spoken in Australia. There was little to no coverage of events in Europe, where the European Union was undergoing enlargement and profound organizational change that would also affect trade with the USA. Ignorance of the outside world was profound and to a degree disturbing.

While our apartment in Tucson did not have the charm of the Grant Crescent house in Canberra, it did have all the modern conveniences expected by Americans, including powerful air-conditioning. Its only drawback was its location close to the flight path of the nearby Davis Monthan Air Force Base. We had a front row seat as fighter jets daily practiced their takeoffs and landings and U2 planes left for faraway spy missions. Takeoffs were generally accompanied by the ear-splitting roars of after-burners. One would think this would irritate the surrounding civilian population no end, but the local radio, TV and press all assured us that this was the 'sound of freedom', to be valued and even enjoyed by all right-thinking Americans.

The military in general was very present in Tucson. Among the residents in our apartment complex, for example, was a military couple, the male partner of which was a 'missile man'. Missile men were career Air Force officers serving a tour of duty manning the Inter-Continental Ballistic Missile silos surrounding Tucson. At the time, there were some 18 underground silos nearby, each containing a Titan II ICBM with multiple

nuclear warheads. Missile men manned the silos in pairs, waiting for the President's command to arm the warheads and launch their missiles. It was an excruciatingly boring duty, mainly because they never expected to launch the missiles. Many used the time that was not devoted to checking and re-checking all the missile's systems, to further their careers through study at the University, as did our neighbor.

Phillipa met him while taking a Russian language course at the University. She was trying to maintain and improve the Russian learned during our recent time in Moscow. He and some of his mates were in the course to improve their Russian to the point they could gain a tour of duty in Turkey, at a listening post to eavesdrop on Russian fighter and bomber crews. Evidently, this was considered a plum assignment on the road of career advancement, as was the tour in the missile silos. Phillipa became friendly with our neighbor and in the course of things we got invited for drinks at his apartment. A number of his colleagues were invited as well, and as the small talk progressed, the conversation turned to a political topic, the nature of which I no longer recall. But I do recall Phillipa's contribution to the discussion at this point: "Well," she said, "I think Lenin was right…" About what exactly she didn't get a chance to say, as the room went instantly and resoundingly silent. The conversation never did get restarted and needless to say, we were never asked around again. I must say, the experience seemed hardly different from the strictures Russians in Moscow showed when talking to foreigners.

The culture shock evidenced by these impressions and experiences was real. Fortunately, our transition to the local way of life was aided greatly by the fact that my grandparents on the Butcher side, Grandpa Ray and Grandma Beulah Mae, as well as Father's brother Bill and his family – wife Lee and children Jenny, Cindy,

Patty and Jim – happened also to live in Tucson. We paid a visit every Sunday morning to the grandparents, and Grandma filled Phillipa in on the history of Father's side of the family as well as on her early life in Missouri. The two became great friends. Phillipa would often help out with shopping and stop by for a meal when I was away observing. Uncle Bill was a physician, an internist in private practice, who was always available for advice, and who often stopped by Grandma and Grandpa's of a Sunday morning as well. He proved to be of great help when we needed to learn to use the US health system.

Shortly after our arrival, I walked up the street from our apartment to the offices of the Steward Observatory on the University campus, and met Bart Bok. Bart was a Dutchman who had studied in Leiden and Groningen before moving to Harvard University. He was Director at Mt. Stromlo before Eggen and at Steward Observatory until 1970. He congratulated me on being the inaugural Bart Bok Fellow and we talked informally about his experiences as Director at Mt. Stromlo.

Next, I was shown to my office, which turned out to be a newly renovated janitor's cupboard in the basement; it had no windows, but at least it did have air-conditioning. I met the engineer who was working on the cassegrain échelle spectrograph I would be bringing into operation and using for my research. I could see right away that the mechanical construction was worrisome; there was too much possibility for critical optical components to shift relative to each other when the orientation of the spectrograph changed, which would be unavoidable as the telescope followed the stars across the sky during the night. I was assured it would not be a problem, and was shown the very powerful image intensifier tubes being prepared for use with the instrument. These devices made each and every detected photon produce a splat on the photographic plate, so long integrations – the kind that would result in smeared imag-

ing caused by flexure among the optical components – would be impossible without well and truly blackening the photographic plate beyond usability. Only short integrations would be possible. This wasn't suited for the high signal-to-noise spectroscopy I was interested in pursuing for studying chemical abundances in the oldest stars, but I could only make the best of it and think about new avenues of research.

It was clear there would be plenty of opportunity to branch out into other areas of research. Steward's offices were located just across the street from the offices and labs of the Kitt Peak National Observatory, the country's main public optical research observatory. Together with the University of Arizona's Steward Observatory, Lunar and Planetary Lab, and its Optical Sciences Center, Kitt Peak made Tucson one of the most exciting places in the country if not the world for doing astronomy.

To see what might be possible, I met and talked to any number of astronomers and engineers doing interesting things. Those people who played particularly important roles in setting my research agenda for the coming few years included the following.

Santiago Tapia, a Chilean who came to the US after the Pinochet coup in his country. We shared ideas of politics in the US and South America, and got on well socially as well as professionally. We worked together on the effects of so-called BL Lac objects located in clusters of galaxies on those galaxies. BL Lac objects are thought to be black holes emitting relativistic jets of material directly toward the Earth. We thought they might be energetic enough to affect the cluster galaxies, but in the end didn't seem to. Santiago went on to build the 3.6-m telescope on Maui for the U.S. Air Force, the first large telescope to correct for image blurring due to atmospheric turbulence.

Massimo Tarenghi, an enthusiastic and animated Italian who later held the posts, first of Director of the world's largest optical telescope, the European VLT in Chile, and subsequently of Director of the largest mm-wave telescope, the Atacama Large Mm Array, also in Chile. I worked with Massimo on combining radio frequency and optical observations of cluster galaxies to try to understand the influence of the intra-cluster gaseous medium on the evolution of member galaxies. This work, together with similar studies with George Miley from Leiden and others, made me acutely aware of the importance of radio observations when trying to puzzle out what is happening to galaxies.

Augustus (Gus) Oemler hailed from the US state of Georgia and was very much the southern gentleman. Gus and I would work closely together using the then newly developed digital detectors at Kitt Peak to try to understand the evolution of spiral galaxies in clusters of galaxies. He later became Director of the Carnegie Observatories based in Pasadena, California.

Roger Lynds, a senior astronomer and instrumentalist at Kitt Peak. Roger was an instrumental genius and formally responsible for the digital detector program at the Observatory. He took a liking to me and let me work with him and his engineers on the earliest development of CCD detectors in astronomy. He taught me how to think about detectors and how to work effectively with prototype (that is, scarcely functional) hardware. His interpersonal skills were worse than poor, however, and I think I can safely say that, over the course of several years, I helped interface him and his program to the rest of the Observatory and to the external scientific community.

Garth Illingworth, who had come to Tucson from Stromlo with his partner, Wendy, prior to Phillipa's and my arrival. I never actually worked professionally with Garth, but we (he and Wendy, Phillipa and me) became

close friends in Tucson, able to empathize with each other's difficulties in the transition from life in Canberra. For several years we got together on Fridays for pizza, sometimes at our house, but mostly at theirs because they had a large swimming pool in the backyard. He went on to a Professorship at the Lick Observatory of the University of California and became an influential voice in US astronomical politics.

It didn't take long before I decided that, all things considered, the new digital technologies being developed at Kitt Peak were far more interesting than anything Steward and the University of Arizona had to offer, and I began spending much of my time with Gus Oemler and Roger Lynds at Kitt Peak. After my Bok Fellowship ran out in 1976, I even managed to land a position at Kitt Peak to work with them on a daily basis.

One day, I mentioned to Gus the issue of the rather short estimated timescales for exhausting the interstellar gas in spiral galaxies as their stars form, which made it seem odd that so many nearby spirals still show copious amounts of interstellar gas. Really, the gas should have been used up long ago, as indeed it has been in certain gas-free disk galaxies in clusters of galaxies. Gus felt these cluster galaxies must either have been formed under special conditions, such that they have been particularly efficient in turning their gas into stars, or they may have had their gas removed by interactions with the other cluster galaxies or with a putative intra-cluster gas. We agreed that an interesting way to distinguish between these ideas could be to look at clusters of galaxies so far away that we could 'see' the galaxies as they were many billions of years ago, when the light first left them on its journey to Earth. Comparison with nearby clusters might then let us actually dissect the evolution of such systems over cosmic time.

It was an exciting idea. There were even a few clusters of galaxies already known that are so far away

their light has taken several billions of years to reach us. The only problem was, even the brightest galaxies in those clusters were very faint, and could only just be detected on photographic plates with the largest, most sensitive telescopes. We needed a better detector. It was at this point that Roger Lynds came to the rescue.

It was 1975 and still the pre-CCD era. Roger's team had started to develop digital TV systems based on intensified vidicons. These were vacuum tubes like the ones used in the cameras in television studios. An image is focused onto a photo-conductive layer, yielding a charge version of the light image, which is then read out by a scanning electron beam. Early TV displays worked in reverse, whereby a scanning, modulated electron beam causes a phosphor screen to glow to produce a light image. The Kitt Peak vidicons were coupled to image intensifiers such that almost every incident photon would make a detectable signal in the digitized vidicon output. The resulting images had the advantage that they were very nearly linear with respect to the incident light intensity (as opposed to photographic plates, which are very non-linear). Our first images had 256x256 pixels, about as large as the available computers could handle. Their field-of-view was small, but just large enough to fit the central portions of the distant galaxy clusters. Roger let us take some test images on the 2.1-m telescope at Kitt Peak. Even right at the telescope we could see that we could detect the galaxies in only a few minutes of integration. It was almost a 'Eureka' moment!

To analyze our images – that is, to turn the red and blue images of the distant galaxies into star forming rates – we had to develop software capable of extracting the signal of each separate galaxy from the digital images. Roger had some initial calibration routines, but these were only available on the Varian 620/F minicomputers that his group used for instrument control. To do our

work, I would also have to learn this software system. Therein lies a tale, one that deserves a short digression.

In 1975 serious digital processing was expensive, because it had to be done on mainframe computers. It was, therefore, mainly employed for analyzing satellite imagery and for medical purposes. We had moderately powerful mainframe computers available at the University and at Kitt Peak, but the large I/O requirement for image processing combined with their universal batch mode of operation made for a data management and storage nightmare on these systems. The first home computers were just appearing and couldn't do much of anything: Microsoft was founded late in the year, to market its BASIC programming language, but it would be several years before the IBM-PC would be introduced. But in the early 1970s an intermediate class of machine had come on the market, the mini-computer. The first of these used discrete transistors, but by the mid-1970s integrated circuits were being employed. Kitt Peak purchased a number of Varian 620/F and HP2100 minis. The detector group used the Varian machines, which had a very primitive set of instructions but a clock cycle of 750 nsec, very fast for the time. Their memory was 32 kilo-words (16-bit words) and disk storage was 5 MB maximum – any additional storage was via 7-inch reels of tape recording at 800 or 1600 bits per inch. These machines were purchased principally for real-time control of telescopes and instruments, but were also available to provide on-line and off-line data reduction capability.

Image processing on the minis was impossible with the available standard programming languages such as FORTRAN, which were very inefficient in their use of machine resources. Luckily, in response to the very limited performance of these early machines, a new language had been developed by the radio astronomers at Kitt Peak, called FORTH. It was an interpreter-based

language, was exceedingly efficient in its use of memory, and was highly interactive. Even better for the instrumentalist, it gave the programmer total access to and control of the hardware. For time critical operations, you could count on knowing exactly how many machine cycles would be required to perform any given series of operations and precisely when they would be executed.

FORTH was, of course, not a mainstream language, so career programmers detested it. But I loved it, and found I was easily five or even ten times as productive in FORTH on the minis as I was in FORTRAN on the mainframes. I started to develop all my research software with it. In fact, I was never again able to enjoy programming in any other language. Roger and the detector group were of the same mind and even when the DEC VAX 11/780 was introduced in 1978, revolutionizing the computing scene and putting all previous minis to shame, we migrated FORTH and kept on using it for our image processing.

Early on in my time at Kitt Peak it became clear that we had the most advanced set of image processing tools for astronomy anywhere. I promoted an effort to bring the suite of tools we had developed into the main stream, so astronomers anywhere could use them on whatever computer they might have at hand. The software system would be called the Image Reduction and Analysis Facility, or IRAF for short, and it would aim to make digital image processing generally available to the worldwide community of astronomers. Of course, this was not altogether altruistic on my part: I also wanted to stop having to support my own software for every Tom, Dick and Harry visiting Kitt Peak, which had become one of my duties; I wanted to focus on new tools for my own research.

The professional programmers assigned to IRAF refused to use FORTH, of course – possibly wisely so, I do admit – but they did agree in principal to maintain

the interactivity and user extensibility that the language provides. The principal programmer for IRAF, one Doug Tody, had been a night assistant on the 4-m telescope on Kitt Peak Mountain and appreciated the interactive power of FORTH in practice.

Alas, as public institutions are wont to do, the project acquired a formal steering committee. As the months went by, the system became less and less extensible by users and its interactive capabilities less flexible. I do not understand that this must necessarily have been so; perhaps it had to do with the requirement that the system should run on any computer, which I accepted as a laudable goal. IRAF has since been called the most 'user antagonistic' software system ever written, an epithet with which I tend to agree. On the other hand, it did become widely used and later was adopted as the official image processing system by NASA for Hubble Space Telescope imagery. Even now, almost forty years later, it is in use at observatories worldwide. After the first year of supervising the project, however, I relinquished my formal responsibility for its further development. It was becoming a system I did not want to use. So, even though I may have started IRAF, realistically I cannot claim any intellectual authorship.

The reason I relate all this, is that the FORTH-based tools led to two discoveries that made me famous – or infamous, as the case may be.

The first was the work with Gus Oemler. We analyzed our test data from the vidicon observations, using Roger's FORTH routines, and found to our surprise that the distant clusters, seen as they were some 3 billion years ago, were full of galaxies very actively forming stars, whereas the same sorts of clusters nearby clearly did not have such galaxies.

We published the result, and were met with an avalanche of criticism – criticism not of the constructive kind. In fact, the result became referred to as the

Butcher-Oemler Effect, by which people meant that the result would be important if true, but of course everyone expected it would eventually be found to be a case of faulty data or faulty interpretation. Historically, most 'Effects' in astronomy are of this kind. Senior colleagues whom I respected greatly told me in no uncertain terms that we were wrong, and that the general commotion surrounding the result, as well as our continued defense of it, would damage Oemler's and my career prospects.

To appreciate why our colleagues felt this way, it is useful to recall the scientific understanding of galaxy evolution in the early 1970s. The most sensitive detectors were photographic plates on the 200-inch Palomar telescope in California. Galaxies could be seen at look-back times of several billion years, but only for the very brightest ones could any detailed information be derived. Now, it turns out that the intrinsically brightest galaxies are all giant ellipticals, which are full of very old stars and show essentially no evidence of evolution beyond the passive evolution of their component stars. All results indicated that the brightest galaxies had been formed early in the life of the Universe and subsequently had evolved passively. In our own Milky Way Galaxy, which is not an elliptical but a typical spiral galaxy, one can count the numbers of stars of different ages, and the conclusion at the time was that star formation in normal spiral galaxies started very early and continued more or less at a constant or declining rate over the age of the Universe. Nearby spiral galaxies may therefore still be forming stars, but if seen in one of the distant clusters of galaxies, they would appear unremarkable and quite unlike the galaxies suggested by the Butcher-Oemler Effect. If correct, our result called into question the conclusions arrived at by a generation of observational astronomers and cosmologists.

Even ten years after our publication, there was no undisputed theoretical explanation for why these dis-

tant cluster galaxies evolved so quickly. Today, people believe that the gravitational potentials in massive clusters of galaxies are lumpy, such that galaxies get nudged repeatedly as they move around the cluster. These nudges in turn are supposed to cause compression of the interstellar gas and subsequently lead to enhanced star formation. The models aren't entirely convincing but they do represent current wisdom.

If galaxies in distant clusters of galaxies were found to evolve differently from expected rates, perhaps nearby galaxies might also be found to have evolved in interesting ways. That is, the new digital tools might be able to probe the histories of nearby galaxies much more effectively than was previously possible.

The nearest serious galaxies to our own are the Large and Small Magellanic Clouds. The Large Cloud is only 1% the mass of the Milky Way and, together with the Small Cloud, orbits around the Milky Way. The Large Cloud clearly shows both old and young stars, so its evolution may possibly have been affected by interaction with the Milky Way and/or with the Small Cloud. It occurred to me at the same time as, but independently of, the work with Oemler, that the Large Cloud might be an interesting test case, namely to see whether a nearby galaxy might also show a very different star forming history from the previously expected evolution. Perhaps the new digital tools would allow one to count stars of different masses and thereby shed light on the past history of the Clouds.

The only problems were (i) the Magellanic Clouds are visible only from the Southern Hemisphere and not from Tucson, and (ii) old stars in the Clouds are very faint, so to count the numbers of stars of different masses a large telescope would be needed. As luck would have it, the Americans were just bringing into operation a 4-m telescope at Kitt Peak's sister observatory on

Cerro Tololo in Chile, the first instrument in the South large enough for this work.

I applied for access, not expecting to be successful, because no one (else) yet had the tools to measure individual stars in very crowded fields such as would be the case in the Large Cloud. But, lo, I was granted 5 moonless nights, and was in fact the very first external astronomer to be granted access to this facility! Surprised and curious, I inquired gently of the local staff in Chile their thinking as to why they had granted me access. To paraphrase, I was told, "Well, because the only thing the telescope can do now is take pictures with photographic plates, and because there is a good chance the telescope itself will not be working well, or even at all, during the initial observing runs, we thought it would be okay to give you, a postdoc with no experience on large telescopes, a shot." Not a resounding vote of confidence in my abilities, but at least I had the access.

A *coup d'état* in 1973 by the Chilean army under General Augusto Pinochet had left the country in a state of lock down. President Salvador Allende had been killed and many of his followers arrested. Even in early 1975, the army was obviously serious about stopping any and all dissent. On arrival, travellers were photographed as they disembarked from the plane, and soldiers were seemingly everywhere. The Observatory had the status of an official international organization, so American astronomers enjoyed a measure of respect from the army. Nevertheless, roadblocks made the trip from the offices in the nearby coastal town of La Serena to and from the Observatory an anxious one.

Normal communication by telephone back to Tucson was almost impossible, as well as being very expensive. Fortunately, the Observatory had a short wave radio, so Phillipa would go to the Kitt Peak offices in Tucson and we would brave the squeaks and squawks, remembering to say 'over' and flip the listen/talk switch at

appropriate moments, to deal with the daily problems being experienced at home and to coordinate my return travel.

It turned out I was able to obtain some beautiful, wide field photographic plates during this observing run. I even had a chance to look briefly through the telescope by eye, which was frowned on by senior staff as a waste of valuable observing time. But I can confirm that such views are beyond spectacular! They also made evident that photographic plates, even when hypersensitized (speeded up) like those I was using, are really insensitive. I could see with my naked eye in a fraction of a second what took almost an hour to record photographically. An uninteresting, if essential, detail was that I was able to calibrate rather well the non-linear response of the plates, thanks to an clever system developed by Bill Schoening at Kitt Peak (who was responsible for the hyper-sensitization equipment too).

On my first night, I did encounter an unexpected problem – management of my bladder. To start observing, the telescope had to be moved to a horizontal position so I could climb in the top-end prime focus cage with my plates. The telescope would then be moved to point at the first field to be photographed and an exposure initiated. The whole process took at least 15 minutes. The plates would typically be exposed for between 45 and 65 minutes. During the exposure, I would monitor the position of a star, keeping it carefully centered on cross-hairs in a small eyepiece at the edge of the plate; this was actually hard work, having to move the telescope small amounts every second or two to ensure the final stellar images would be small and round. The nights were less than 6 hours long, so the bottom line was that any time taken to climb down between exposures for a bathroom break could lead to the loss of one whole exposure. Who knew whether that exposure might provide the essential key data to make my project

a success? The first night was agony – I was sure I would burst, but thereafter I not only took an empty emergency bottle aloft, but also was careful not to drink anything for six hours before observing.

When back in Tucson, I digitized the plates, linearized their response, and using new software routines I had written, I measured the so-called luminosity function and derived the distribution of stars with different masses and ages. When compared with the luminosity function of the Milky Way, it was clear that the major burst of star formation in the Large Cloud had occurred some 5 billion years ago, rather than 10 billion-plus years ago as in the Milky Way. Here was a galaxy with a very different evolutionary history, even though it appeared in its *integrated* properties to fit the then current view that most star formation in galaxies had begun very early in the life of the Universe and proceeded fairly peacefully from then on.

I was very proud of this result. It was clean, unambiguous, and would likely open up a whole new industry of determining the star forming histories of nearby galaxies (which after a while it did). I went on a lecture tour to many of the important astronomical centers, both to tell colleagues about the result and to promote the power of the new digital techniques for photometry. Again, I was met almost universally with skepticism and disbelief. Not until others would repeat the measurements, which they could not do until they had the software routines of IRAF, would the result be widely recognized. I had no problem with that, but the unpleasant and unwarranted criticism wounded. Of course, in the following decades, as the detectors improved, the result was confirmed by several different, independent methods. It is now generally accepted that the many small companion galaxies to the Milky Way have all had individual evolutionary histories, although there remains little insight into why that might be the case.

About this time (mid-1977), Phillipa and I started thinking about starting a family. We realized there might never be an ideal time, but my work was being valued at Kitt Peak, so there was now a reasonable prospect for continued employment, and Phillipa had not yet found a job she wanted. So, we bought a house at 2247 E. La Mirada, within easy walking distance of the University and the Kitt Peak offices. This was a three bedroom, single story unit with palm trees in the front and a walled-in back garden. A family wouldn't be complete without a dog, of course, and in short order, Muffin, an adorable basset puppy, joined us. Next, we came off the pill and bingo! it was too late to reconsider.

The pregnancy went smoothly, and we both attended Lamaze classes so I could provide support during the event itself. Actually, I wasn't much use at the critical moment, but at least we helped the Tucson Medical Center christen its brand new 'Birthing Room'. This was a room in the hospital set up supposedly like a living room in a home, but actually rather more like in a hotel room – more homey than the operating theater, certainly, if hardly like home. Phillipa was to sit on a bean-bag chair, which during the critical phases didn't cooperate, but otherwise things proceeded without difficulty.

Jeremy put in his appearance on 5 June 1978. In this he was very considerate, presenting us with a birth date of 5-6-78, which even I can remember. He weighed in at 9½ lbs and was completely healthy. Except for his skin, that is, which was dry and scaly: 'ichthyotic' was the term used by the hospital – showing fish-like scales. The condition would quickly develop into eczema and require slathering with soothing creams several times a day, every day, every week, all year. He began to have trouble sleeping and Phillipa spent many nights by his bed to help him get calm enough to sleep. The condition would later be diagnosed as aggravated by allergies to the local pollen, dust, house mites and the like, and

would ultimately be an important reason for us deciding to leave Tucson for a different, wetter climate.

Jeremy grew normally in weight and ability. By the time he was mobile, the weather had become what Tucson takes for winter, so he could play outside. We used cloth diapers on Jeremy, and the weather was so warm we had to buy hardly any other clothes for him.

From time to time, we invited Illingworths and other acquaintances around on a Friday evening for pizza and beer at our house. One such evening, as Jeremy sat in his high chair, he uttered his first word – 'pizza'. This would come to characterize his speech in general: Jeremy would never say much, but when he did speak, it would be very clear what he wanted.

Our neighbors on La Mirada were mostly middle class, some raising a family, others elderly couples or individual ladies living alone. It was a sedate and quiet neighborhood, except in the middle of many nights. Drug smuggling from Mexico was a thriving industry and the nearby University an important retail outlet. When observing at Kitt Peak mountain, some 90 km west of the city, one could often hear the smugglers' planes below the mountain as they skimmed the desert floor flying under the radar. Together with illegal drugs comes crime, of course, and police sirens and helicopters provided us with almost nightly serenades.

Mostly we experienced little directly of these dramas, but we did get burgled three times during our nine years in Tucson. Perhaps 'burgled' is not the appropriate word, however, as the intruders never actually took anything, probably because we were not very well off and really had nothing worth stealing.

At first, we imagined Muffin would deter any break-in, because she could howl with booming abandon when she wanted. But it became clear after one break-in that she must have welcomed the company, because when we returned home, the burglars had left an empty

carton of milk on our table in the back garden. They obviously had had plenty of time to sit and enjoy the garden without worrying about being disturbed.

Although I judged it unlikely we would ever experience any violence ourselves, the prevalence of crime nearby did bother Phillipa. When I was away for several days at a time observing, she would shift a matrass to the front door and sleep jammed up against the door with a knife under her pillow.

As Jeremy turned a year old, we decided to spend a month in Europe. We realized travel would be much more difficult once he became a 'terrible two'. So now would be the best time to travel. I got myself invited to present my research and talk to colleagues at the European Southern Observatory (ESO). This was a relatively new international organization, formed in the 1960s as a vehicle for European countries to collaborate in building and operating large telescopes in Chile. In the early 1970s, its European headquarters and labs were hosted at CERN in Geneva. We flew in to Amsterdam, rented a car and first visited with an astronomer acquaintance from Kitt Peak, Galen Gisler, now working in Leiden. He told us about living and working the Netherlands, which sounded attractive. We could not know this first contact with the country would herald a life long involvement.

In Geneva, we were received in a very friendly manner. I even got shown around the underground tunnel for the Super Proton Synchrotron and its high energy particle detector labs. Phillipa and Jeremy explored all the playgrounds and building sites in Geneva, builders having caught the young man's imagination. I gave my talks and told about our software and our work on CCD detectors, about which more later. While the ESO labs were not working at the level of ours at Kitt Peak, they were clearly gaining experience and had enough

funding to ensure competitive detectors would ultimately be developed there.

After Geneva, we drove to Paris and on to the UK. While Switzerland was strewn with public playgrounds for children, France was a desert in this regard, making the trip a bit of an ordeal. Our intention had been to drive to Scotland for a short holiday, but by the time we got to Calais, we were very tired. Exiting the ferry at Dover, we decided to turn right and stop at the nearest country inn for several days, which turned out to be at St. Margaret's Bay. A very English establishment it was, reminiscent of the Miss Marple shows on the BBC – manicured garden, afternoon tea with scones, and so forth. The hotel part of the establishment was run by the wife, a French lady, and the pub part by her English husband. Jeremy behaved himself fairly well we thought, given the rain and unfamiliar surroundings, although the proprietress did give us dirty looks from time to time.

Upon our return to Tucson, Phillipa decided to go for a certificate at the University that would qualify her to teach children with learning disabilities. This meant day-care for Jeremy. Luckily, we found a Mormon family willing to look after him for several hours each day. In the western parts of the US, one finds many Mormons. They have what for us are strange religious beliefs, but they are very well organized as a community and are exceedingly family oriented. Jeremy was not at all pleased to be dropped off each day, but generally had a pleasant time once Phillipa had departed.

After qualifying, Phillipa got a position as a Remedial Education teacher at the Canyon del Oro high school. She learned to accept that many pupils at the school drove more expensive cars than she did, that police with guns would be present at times, and that she was expected, if not actually required, to attend pep rallies and football games. She remarked that the pep ral-

lies had much in common with Hitler's Nazi rallies of the 1930s – whereby attendees were whipped into a frenzied call to 'slaughter' the opposing team. As the year concluded, she said that it had been a good year, for none of her remedial pupils had ended the school year in jail.

Phillipa's parents were not great travellers, but they couldn't stay forever away from their first grandson. Many Australians felt acutely their antipodean isolation, and when they did travel overseas they often spent a long time away from home. Les and Shirley Newton came to visit for a year. Luckily, the house at La Mirada had the extra room, and while I now had come to subscribe to the Dutch maxim that 'Fish and visitors go off after three days,' the Newtons were exemplary guests. Indeed, this was a period in which I was away from home, mostly observing, nigh on a third of the time. The Newtons frequently arranged to be away visiting acquaintances in the US and Canada while I was home, and were careful to be present and help while I was absent. By all accounts, they enjoyed their stay, and I know Phillipa and I greatly appreciated the effort they made to fit in with our busy lives.

My research on distant galaxy clusters with Oemler and on the Magellanic Clouds continued, the goals being to ensure that the previous results were verified in every way possible. But I also branched out to work with Holland Ford at Kitt Peak and later with George Miley and colleagues from Leiden on exploring the inner workings of radio galaxies. The latter are apparently normal galaxies that show strong emission at radio frequencies. They were and are believed to have massive black holes in their centers that are the ultimate driving force of the radio emission. The linear response and large dynamic range of the new vidicon detectors allowed one for the first time to model and then remove the starlight from galaxy images, leaving only whatever

optical emission might be emanating from other sources such as the material around the black hole. We discovered galaxies with narrow optical jets streaming out from their centers, and also warm gas falling into the centers, presumably 'feeding' the black holes, producing radio emission and occasionally also optical jets.

In the detector lab, the team had started playing with the earliest CCD detectors. This was a wonderful development because even though the vidicons were an improvement over photographic plates, they were moderately unstable. That is, they employed scanning electron beams, and these were susceptible to changing electric and magnetic fields in the environment (even though we shielded them carefully). Hence, as the telescope moved to follow celestial objects, there were always minute image shifts that could not be calibrated. CCDs on the other hand are all solid-state devices – their geometry cannot change. They do suffer from various charging and lag effects as the accumulated charge is shifted through the underlying silicon layer to the read-out amplifier. But compared to electron-beam devices they are wonderfully stable and photometrically more reliable.

I became deeply involved in exploring the use of these detectors for astronomy. The first two-dimensional CCD that was commercially available was a 100x100 pixel chip from the Fairchild Semiconductor company. It was introduced in 1974, and we started seeing how to use it for astronomy late in 1975. The sensitivity was not high – actually no better than the best photographic plates – and they were sensitive not only to light but also to cosmic ray muons, which caused large comet-like splats as they passed through the chip substrate. But the technology improved every year as the U.S. military began to put them on their spy satellites and NASA promoted them for the Hubble Space Telescope.

By 1978 I was formally named Project Scientist for the CCD imaging systems being designed for use at Kitt Peak telescopes. We built a delightful, portable package to operate these detectors, the electronics and control system all fitting in one 19-inch rack. The system included real-time, multi-tasking software that could also reduce the data in the background while observing progressed. The principal systems deployed at Kitt Peak were cameras for imaging and for a new low resolution, multi-aperture spectrometer that could take spectra of many, very faint galaxies simultaneously, albeit over a limited field-of-view on the sky. The latter was ideal for verifying the Butcher-Oemler Effect, which of course is what I used it for.

While I was becoming thoroughly involved in the instrumentation program at work, we decided Jeremy should have a sibling. By the Christmas of 1980, we were pregnant again. This time the pregnancy was not so smooth. At about 6 months, I awoke early one morning to Phillipa having a *grand mal* seizure in the bed next to me. I panicked, feeling completely helpless, but did manage to telephone 911 for emergency help. The paramedics arrived in less than 10 minutes (impressing the hell out of me by their quick response). By this time Phillipa was no longer in the midst of the seizure, but neither was she fully conscious. They administered oxygen and took her away, while I stayed home to look after Jeremy. Seizures during pregnancy are often a sign that something has gone very badly awry between mother and fetus. They can be life threatening for both mother and child. Often the only treatment is to terminate the pregnancy. In our case, however, the diagnosis was not clearly indicative, and in the end the pregnancy was allowed to proceed.

So, one morning Phillipa noticed mild contractions. I was immediately ready to go to the hospital, while she insisted they were so mild that they must be

false labor. After some argument, she agreed to phone the doctor and let me drive her to Tucson Medical Center, where several hours later Christopher Thomas emerged. Again, his arrival did not go smoothly. There was considerable blood, which covered the floor and on which a nurse slipped, fell, hurt her coccyx, and had to be carried out of the delivery room for examination elsewhere in the hospital. But CT, as he quickly became called, was by all accounts a perfectly normal infant. He even had his delivery on Bastille Day (14 July 1981), so I am able to remember his birthday too.

The CCD work at Kitt Peak was now becoming widely recognized. The group at Cerro Tololo generally did all their own instrument development, but when offered a copy of our system, to my surprise they accepted. It meant I would have to go to Chile for several months to install and commission the system in their particular environment. The Observatory agreed that the stay was long enough that Phillipa and the boys should accompany me.

It took some months to prepare the copy system. In the meantime, Phillipa took the boys for two months to visit Nanna and Poppa (grandparents Newton) in Brisbane. But in mid-March 1982, the four of us arrived in Santiago for a three-month stay in Chile. Our first night was spent at the ESO guesthouse in Santiago, an old-world establishment run with an iron hand by an elderly German lady. Right away, Jeremy distinguished himself by slipping and falling into the large goldfish pond in the courtyard, frightening the fish so much they refused for days to come out to eat. We did not endear ourselves to the management.

A day or two later we made the 8-hour trip in an Observatory car to La Serena, the seaside town where the Cerro Tololo Observatory has its headquarters. We were given a house in their fenced off compound, which came with a maid and a gardener. This was unexpected.

We were not keen on having servants, but were informed that nearly everyone in Chile had servants, even our maid had a maid at home, we were told. They were inexpensive and came with the house, so there was no point in resisting. We could adapt.

The Chilean secretaries working in the compound's office spoiled Jeremy and goo-ed and coo-ed over CT. We explored La Serena and the surrounding towns, met astronomers from other observatories in the area and went to the beach. A cold current hugs the coastline from La Serena on north to the deep Atacama desert, making the prevailing atmospheric airflow onto land both smooth and cloud free, just right for astronomy, but too cold for pleasurable swimming. The local economy included an active fishing fleet, and the nearby port town of Coquimbo had a fish market where the fish were so fresh the market didn't smell of fish at all. We borrowed an observatory car one weekend and drove to the ESO telescopes at Cerro La Silla, a three-hour drive northwards along the coast and through the desert. CT cried the whole way… We later concluded that he just could not sit still, and being confined in an infant's seat belt drove him almost into a frenzy.

At La Silla, I saw that the European facilities generally lagged behind the American competition, except in one area. Their 3.6-m telescope had an échelle spectrograph in its coudé room, which was set up to provide very high spectral resolution (equivalent to 2 to 3 km/sec velocity resolution) and to do so very efficiently. It also had a highly efficient photodiode array as detector (a Reticon, produced by a spin-off company of Fairchild Semiconductors, of CCD fame). We had nothing like it, and I decided I really, really wanted to use this spectrograph for studies of the evolution of chemical abundances in the Galaxy. I enquired as to how I might gain access, to be told that I should either collaborate with an established astronomer in Europe, or take a job

in a European country – the latter remark planting a seed in my thinking.

It took most of our three months in Chile to bring the CCD system into full operation on Tololo, and to teach the local staff its operation and maintenance. Each weekday, I would drive from the La Serena compound to Cerro Tololo, almost an hour's trip. The road ran through a farming valley, and along the wayside, as it ascended into the Andean foothills, one could see large colonies of burrowing parrots. At the summit, one regularly saw the giant Andean condors, the ones with the three-meter wingspans, gliding past the mountain top. On occasion, the kitchen staff would set out meat scraps. With luck, one of these spectacular creatures would land, walk right up to the kitchen door, and leisurely proceed to partake of the feast while we all watched in fascination. Late afternoon on still days, as one sat outside to enjoy the cooling air, vinchucas, also called kissing bugs, would advance across the desert ground, evidently attracted by our exhalation, skin odor, and/or warmth. These insects were a constant worry because they carry the parasite for Chagas disease, which initially is asymptomatic but later on can become fatal. Usually they bite near the mouth (hence 'kissing bug') while one is asleep, so the Observatory kept their dormitories very clean and well sealed.

Upon our return to Tucson in mid-June, I found the Kitt Peak organization in turmoil. The Director, Geoffrey Burbidge, of stellar nucleosynthesis fame, had been redirecting resources to improve support for external users of Kitt Peak telescopes and to promote a new, giant telescope project. Laudable goals both, but as a theoretical astrophysicist Burbidge gave the impression that he did not value technological innovation, nor indeed to perceive a central role for the local engineering and research staff. And the giant telescope project was becoming bogged down by political in-fighting among

university groups in California and Arizona, so Kitt Peak's role in leading the project was in jeopardy; a few years later the Kitt Peak project was indeed cancelled, to be replaced by privately financed facilities in Chile and Hawaii. Productive colleagues were beginning to leave Kitt Peak for jobs elsewhere, and the future of innovation at the organization was not at all clear.

It was at this point that Harry van der Laan visited Tucson. He was director or chairman of important astronomical institutions in the Netherlands, including the Dwingloo-Westerbork Radio Observatory, Leiden Observatory, and the Dutch National Committee for Astronomy. The Dutch had recently concluded an agreement with the British to help build a new optical observatory in the Canary Islands, and van der Laan was looking for an optical instrumentalist to run a Dutch technical team as part of their contribution to the collaboration. Someone had mentioned my name to him, and he invited Phillipa and me to visit the Netherlands, at his expense, to see whether we might be interested in my taking up the position. He was very persuasive.

Before taking van der Laan up on his offer, Phillipa and I talked at length about whether this might be an interesting move for the family. Phillipa was clearly looking for a change of climate for Jeremy, who still suffered from eczema and chronic bronchitis. The doctors' advice was that we should either have him desensitized, or we should move to a very different environment. Phillipa also said her experience teaching at Canyon del Oro high school made it blindingly obvious that we should not want our boys schooled in the US system. Indeed, the American culture generally – with its emphasis on the individual, on competition, and on material gain – was not our idea of the best society for our children. The Dutch job was worth a look.

We arranged to spend a week in September touring relevant institutions and talking to people about liv-

ing and working in the Netherlands. We liked what we saw. The damp, cool climate would almost certainly be ideal for Jeremy; the schools seemed excellent; and I was impressed by the technical competence of the radio engineers in Dwingeloo. The job itself would be as a full professor at the University of Groningen, Director of the Kapteyn Observatory in Roden, and leader of the combined teams of instrument-makers from the universities of Groningen and Leiden. And, with my background in optical astronomy and experience with instrumentation and detector development, I could see that I could make a difference.

Phillipa investigated the housing market and even found a satisfactory house at Floralaan no. 8 in Roden, across the street from an elementary school, around the corner from a supermarket, and within walking distance of the small Kapteyn Observatory where I would work. It was located at the edge of the village, and it looked out on a large grass square of public land, and beyond that onto peaceful paddocks with milk cows ambling about. She also confirmed what we had been told, on the one hand that the Dutch culture was family oriented, which was good, but on the other that it was not obvious what the opportunities might be for her career. On the short term, she would have her hands full with settling the boys into life in a new country. Later, we would just have to see. On balance, we agreed it seemed an interesting possibility. If it didn't work out, we should be able to get jobs somewhere else.

I formally applied for the professorship in Groningen. Some months later I received word I would be offered the job. We immediately made an offer on the house in Roden, which to our delight had not yet sold. Our offer was accepted. It was time to move to Europe.

Historical remarks

Americans seem to have great difficulty coming to terms with adversity. In the period of this chapter, the loss of the Vietnam War, the Nixon resignation following the Watergate scandal, the Helsinki Accords of 1975 which formally recognized Soviet hegemony over Eastern Europe, capitulation to China on the Taiwan question, reversion of the Panama Canal to Panama, the Iran hostages crisis, and economically, the rise of inflation, unemployment and the federal debt, combined in the national consciousness to send the country into a mood of despair.

By 1980, the nation longed to re-embrace American exceptionalism. Ronald Reagan won the Presidency that year on a message that the US is the best country in the world and serves as a 'beacon of liberty' for the rest of the world. He rejected social liberalism and promoted *laissez faire* economics: "Government is not the solution to our problem; government *is* the problem." The social contract of Roosevelt's New Deal of the 1930s was rejected and replaced by an ideology of individualism and the benefits of unfettered economic activity. To be fair, Reagan did reduce inflation and unemployment, and he himself was passive regarding the existing welfare system. It would be later in the 1990s that the religious right would argue for a program of dismantling the social safety net, while at the same time wanting to use government to enforce moral behavior. Reagan cut taxes to stimulate the economy but spent heavily on the military, in the process tripling government debt. A virulent anti-communist, he increased the use of the CIA to foment right-wing coups in Latin America and install dictators who were accommodating to American commercial interests.

For science, the US government had no coherent, long-term policy of support. Indeed, since World War II, multiple agencies (*e.g.* NASA, National Science Foundation, Department of Energy, Department of Defense, etc) have provided finance according to their own perception of requirements and with only occasional inter-agency cooperation. The one thread of policy that has been consistent since World War II has been a political desire that funding should be provided only if it ensures pre-eminence and leadership of the United States.

A growing distrust of science among the US populace became evident at the end of the 1960s. From the early 1970s, Federal funding of general science (that is, non-military and non-space science) stagnated and remained essentially constant (in inflation-corrected dollars) for the next two decades. New initiatives could only be financed by stopping existing activities or closing existing facilities. It would no longer be automatic that America could continue its global superiority in science. At Kitt Peak, the evolving research needs of the astronomical community became harder to accommodate. By the mid-1980s, the forefront technological capability built up in the organization's earlier years became impossible to maintain. The organization has never fully recovered and no longer plays the pre-eminent role in US astronomy.

Chapter 9
Hooggeleerde heer

The Dutch appear a friendly lot: kind, polite and helpful to tourists. …The Dutch reputation for tolerance is all too apparent to the foreign visitor. But do not let this image fool you – it changes drastically if you stay long enough to become part of the scene.
– White&Boucke, in *The UnDutchables*

It is a curious Dutch custom when selling a house, that all items and appliances that physically can be removed are removed. In many cases, even small plants in the garden are taken away by the sellers. When Phillipa and the boys arrived in Roden from Australia in mid-August 1983, thoroughly jet lagged, they were confronted by our nice new house, the papers having been signed by me only days before, which not only had no clothes washer or cooking stove installed, but also no lights or carpets. Bare concrete served as floors, and sad little clusters of wires protruded at intervals from ceilings and walls. This was not at all what the house had looked like some months previously when Phillipa had inspected it. This was as depressing as it was unexpected, the first instance of culture shock in our new country. To

make matters worse, a week later, I had to travel to Chile for an observing run, leaving Phillipa to deal with settling in. Our marriage was touch and go for a while.

Luckily, an Australian colleague working in Leiden, Colin Norman, was in the process of moving to the United States, and he offered to provide us with all his Dutch appliances. They were to serve us well for almost 20 years.

In the weeks that followed, we organized for the electricals, had oaken parquet laid on the ground floor and carpets upstairs, and purchased basic furniture. Later, we even knocked out a wall to make the living area roomier, installed double glazing in the windows and added wall insulation, and put in an efficient central heating unit. Years later, we had the kitchen and living room enlarged, such that the house became a wonderful refuge for both of us from the trials of daily life at work.

Jeremy could start school immediately. We expected to attend the public school across the street and had no trouble enrolling. His kindergarten teacher was juf Greetje (Scholten), to whom we owe an enormous debt, one that can never properly be repaid. She received us in a warm manner, in English, and was most solicitous to a shy and rather frightened young boy. After six months of class, she let us know that he had spent the first months sitting under a table, unwilling to join the rest of the group. She explained his behavior to the class by reading to them short texts in English, telling them that he had the same problem of understanding Dutch as they were now having, but in reverse. Ultimately, she coaxed him out and at six months he was joining in nearly all activities. Evidently, it had taken him that length of time for his Dutch to become adequate for him to feel able to participate. So much for children learning language easily.

In general, we were very pleased with the school. Not only was it just across the street, but the children were carefully evaluated on their individual progress, not in relation to any other pupil. The only difficulty we experienced was that the school closed for lunch. That is, it literally shut and locked its doors for ninety minutes at lunchtime. We enquired about child-care, but there was nothing structurally organized. Except in family run shops or on family farms, it was generally accepted that mothers would not be working. The long lunch hour allowed adequate time for farming families to have their main meal of the day at noon. Mothers would arrive on bicycles and chat among themselves while waiting outside the school for their young ones, to take them home on a child-seat 'achterop'. A school bus was available for children who lived on the most outlying farms.

On the one hand, the situation made for a leisurely and friendly, family oriented social environment. On the other, it meant that Phillipa could not realistically expect to be able to work while the boys were of school age. This was a second major shock that would lead to considerable frustration in our new life.

My own transition to the new environment was a far more positive experience. I had travelled from Tucson two weeks before Phillipa arrived from Australia. I flew with our basset hound, Muffin. While I waited for my luggage at Schiphol, somewhere from deep in the bowels of the airport came her deep-throated, mournful baying. As she came up onto the baggage carousel and was let out of her crate, the assembled travellers enjoyed her gleeful bark as she recognized me. She and I travelled by train to Groningen and then by taxi to Jan Willem and Titia Pel's house in Roden, where I was received most warmly, and in English. Jan Willem was an astronomer at the University and quickly became a valued friend and colleague.

While we had taken some Dutch lessons from a private tutor in Tucson, I quickly found I could hardly follow normal conversations, and I experienced the frustration and frequent anxiety of not being able to express myself. The Pels were patient and tolerant, and in many other ways were most helpful. I observed that they spoke French, German and English equally fluently on the telephone, and Jan Willem was reading Kant in the original German. I was enormously impressed and felt I was quite out of his league. But I must say, later I came across other Europeans who were certifiable idiots, fluently, in four or even five languages!

Jan Willem introduced me to Roden, explaining the village layout and how public transport worked. He helped me at the *notaris* with the house purchase, and took me to the Kapteyn Observatory. Located in a beautiful, wooded area about a kilometer from the village center, the Observatory had a small (60-cm) telescope, although in recent years the facility had functioned merely as a mechanical and electronics workshop. The technical team numbered 15, and had been formed the year before from the technical staffs from the astronomy departments of the Groningen and Leiden universities. These gentlemen – all men, as it would be many years before females began to appear in Dutch astronomical circles – spoke poor English, and I could tell right away that even my limited Dutch was appreciated. I could see there was a tension between the Leiden and Groningen groups, and of course a skeptical attitude toward their new American Director. I noted there were neither numerically controlled machines in the workshop nor computers of any kind in use. Technical drawing was still done by hand on drawing tables. When I queried, I was informed that written documentation was not seen as important. The accepted procedure was for the astronomer to provide a sketch of something he wanted built, and the instrument-makers would then figure out how

to make it, and subsequently maintain and/or enhance it as indicated by experience.

The mission to help build instruments for the new UK/NL observatory in the Canary Islands would require a radical upgrade of capability and a complete revamp of working habits and protocols. The backlog of small university projects, which had been started in previous years but never completed, was daunting; I would have to put a stop to most of them if the group would ever become productive in its UK/NL mission.

The Groningen University was to be my formal employer, and my formal place of work as a professor would be the Kapteyn Astronomical Institute, located on the opposite side of Groningen from Roden. It took about an hour by bus to reach my office there. On my arrival, here too I was received in a most friendly and hospitable way. The staff were half foreigners and so the *lingua franca* was English. Although most of the senior academics were radio astronomers, everyone seemed in favor of – or at least not averse to – the planned increase of optical research activity through the UK/NL collaboration. I could see after several weeks that the level of discourse and, indeed of research, was very high. I would enjoy the interactions with my colleagues there.

I noted that only the full professors seemed to be able to afford to own an automobile. Everyone, even those with a car, seemed to rely mostly on bicycles and public transport. While I had often taken lunch at local restaurants in Tucson, here people only very rarely could afford to eat out. My colleagues were not poor by any means, but the general level of personal wealth and comfort was significantly less than in the US.

Now, I had a letter from the Groningen University confirming my employment as a full professor, but professors were royal appointments and the Queen was taking a long time to do her part (which of course she finally did). The University was kind enough to provide

a salary advance, but in the process I learned that I would be earning some 10% less than I had been promised.

I was furious at this development. I had accepted the position based on an agreed salary, had bought a house and arranged a mortgage in the expectation of a certain level of income. Our initial expenses were relatively high as well, among other reasons because we had no winter clothes, having lived the last nine years in Tucson. I felt it was simply unacceptable that the University would renege on their side of the employment agreement.

This would, however, turn out to be yet another instance of culture shock, in time to be overcome. No one, either in the administration or among my academic colleagues, had any problem with the situation. I was told I should just accept it: the economy was doing poorly and everyone had to contribute to keeping the government running properly, including those of us working in public service. It was an attitude of solidarity, that the group is at least as important as the individual. In other words, the government is us, and we all should work together to deal with problems, be they financial or social or whatever they may be.

It took a while to become comfortable with this aspect of Dutch life, but I would come to feel it ultimately makes for a more pleasant society in which to live. Unfortunately, as Thatcherism took flight in Britain, its extreme model of capitalism also made inroads in continental Europe. Two decades later, the emphasis in Dutch society had also shifted perceptibly toward the individual, although it is even now not as extreme as in the UK or USA or Australia.

The collaboration with the British on the island of La Palma involved the Dutch providing 20% of the manpower and funding, both for the construction of telescopes and for the instrumentation that would make the

facility scientifically productive. The Dutch were especially interested in the latter, and participated actively in the various committees charged with defining the observatory's scientific capabilities, and of course also with those monitoring the financial health of the overall collaboration. Although all educated Dutch speak excellent English, I was almost immediately asked to represent the community on several of these committees.

I took this as a major vote of confidence in my abilities. Until, that is, over a beer one evening, I asked a Dutch colleague why I was put on the important management committee, given that I had only just joined the Dutch astronomical community and as yet didn't know it well enough to be sure I could represent it effectively. The answer was telling – to paraphrase: "We understand the words the English use, but evidently not always the meaning, which often seems to involve a cultural context we do not understand, and seems often to include hidden agendas. Perhaps as a native speaker you can function more effectively than we."

I quickly learned what my colleague meant, that many declarations by our English colleagues did indeed not mean strictly what the words said. One example: When the English say, "It is an interesting suggestion. We will look into it." they mean, "Don't be silly. That will never happen." It took me most of my first year to decipher such language, and to appreciate that the detailed language in meeting minutes was almost always purposefully imprecise or admitting of diverse interpretations. In fact, it was only when a friend suggested I consult the book from the BBC TV series *Yes, Minister*, an extraordinarily insightful (and amusing), fictional tale of the British public service, that I began to feel confident I could understand most of what was being said in our joint meetings.

It took longer to appreciate fully the consequences for the overall program of the culture in which our Eng-

lish colleagues functioned. Only when I became chairman of one of the top-level policy committees did I gain sufficient behind-the-scenes access to information that I could see the reasons why the joint programs were always on-time and on-budget in our formal meetings, while in reality they were manifestly over-budget and taking longer than planned. The English administrative team would come together privately a month or six weeks before the formal international meetings, to reorganize the budgetary and resource planning numbers, such that the current situation would appear to be on-time and on-budget according to this revised program, while any detailed comparison with previous planning would be made nearly impossible. Matters had to go grievously wrong before top-level policy people would become aware that something might be amiss.

This did happen once in my experience, and just as on TV, a 'blue ribbon' panel was formed that took a year to report. By then of course, the English administrators could say they had already taken corrective measures and there was no need for the policy committees to consider the panel's recommendations further. It was an unreality that could not be imagined in the Netherlands, but as 20% partners we could not expect to change this feature of British culture.

Our part of the program at the Observatory in Roden was to design and build the TAURUS-II instrument, which was destined to be one of the important early scientific capabilities on the new 4.2-m William Herschel Telescope, then under construction on La Palma. We contracted for the hardware and software, excepting for the Fabry-Perot interferometer, which was the heart of the instrument and which would be provided by Queensgate Instruments PLC, an English company.

The project would also be the vehicle with which I would attempt to professionalize the technical team in

Roden. TAURUS-II would have to be well documented because the operational team on La Palma would have to maintain it. And the software would have to follow professional standards as approved for La Palma.

From the start I could see this process would be a sociological challenge. It wasn't that the team resisted. What became evident was that they were wary of accepting tasks without the necessary tools to carry them out. As Director, I would have to ensure that the technical environment was conducive to a higher level of performance. Also, they were very concerned that they would be blamed when mistakes were made. The consequence was that we had great difficulty spending money quickly enough to meet the schedule agreed with the British. That is, the team was very reluctant to spend money if there was any possibility that the result might not prove successful. Partly this was Dutch thrift, but partly it had to do with what I slowly came to realize, without at the time having a name for it, was that we lacked expertise in 'systems engineering'.

My solution was to proclaim that money should be seen as the oil that would make our project run smoothly, and therefore had to be spent, but also that I as their Director would accept any and all blame for whatever mistakes might be made. Of course, before I was believed in this, I actually had visibly to assume blame for one or two difficulties, which were not long in coming and after which the effort aimed at professionalization gathered pace. While the TAURUS-II instrument in my opinion was a rather amateurish product, it was the first instrument available on the new telescope at first light in mid-1987, and this gave the group in Roden the confidence to move on to greater things.

Of some interest in this story is the struggle to develop the TAURUS-II software. We initially had no computer in Roden. Indeed, this was a period when computers were very scarce generally at Dutch universi-

ties. A main-frame was available in Groningen, but it was of course not suitable for instrument control nor compatible with La Palma standards as determined by the British. Funding to purchase an appropriate computer proved to be the least of my worries: I discovered that we would first have to gain approval from a committee at the departmental level, then from one at college level, followed by one at university level, and then finally a committee in The Hague had to approve all requests for computers from around the country. We could then negotiate for the approved purchase with a central national purchasing authority; we could not purchase a computer ourselves.

The IBM-PC had just become available in Europe, and even the purchase of one of these machines had to take place according to this protocol. It took about a year, but eventually we obtained a DEC VAX-750, which would be compatible with the machines planned for La Palma. Ultimately, pragmatism would prevail, and within two years, only the largest machines had to be approved and purchased following the previous protocol.

While much of my time was unavoidably spent on these organizational matters, I forced myself to make time for at least a modicum of personal research. I had previously set a course to study the evolution of galaxies. I was able to continue to collaborate with Gus Oemler and others on galaxy evolution in galaxy clusters over cosmic time, and also on determining the star forming histories of nearby systems in which one could measure individual stars. But other avenues of investigation were also becoming interesting.

In particular, for some years, physicists had been pondering a discrepancy between the predicted and measured flux of neutrinos from the Sun. It was not known whether the problem lay in the understanding of neutrino physics, or in an incorrect model for the interior of the Sun. There were reasons to imagine it might be

either, or both. If the culprit was the solar model, then the timescales for stellar evolution in general might be systematically called into question. These timescales depended almost entirely on theoretical modeling of how the interior structures of stars evolve with time as their core hydrogen is burned. In mid-1985, a French group reported seismic measurements of the nearby star, Alpha Centauri A, which departed significantly from the predicted values. Perhaps our age estimates for even the nearest stars were incorrect.

Over a beer with the British colleagues from Queensgate Instruments, we discussed how stable the Fabry-Perot interferometer in TAURUS-II could be made, for example by re-engineering its active control system. A short while later, I received word that they thought they could reduce the electronic noise and stabilize the system to an rms level of perhaps ±30 cm/sec in velocity. I judged this should be adequate to detect the seismic signals from Alpha Centauri A, and in 1985 we set about designing a so-called stellar seismometer based on a custom Fabry-Perot system from Queensgate.

It was a very long and at times rocky road, but eventually the necessary funding was secured (from a total of 13 different sources) and the instrument built. Our role in Roden was to design a thermal stabilization chamber to hold the Fabry-Perot etalon optics at a constant temperature to within a milli-degree, and design a fiber-optic feed system to scramble and stabilize the optical illumination of the etalon. If both we and the Queensgate team were successful, the seismic signal would be of the order of 5 milli-percent of the starlight flux, small but easily within the realm of existing detector technology. I was the systems engineer for the project, and I learned an enormous amount of optical and thermal engineering in the process. I also learned about real-time control using an IBM-PC clone, in our case an

Olivetti M24. It turns out this was just possible given the way DOS interacted with the hardware; that is, as long as all one needed to do was send a trigger to an external analog-to-digital converter, the PC clock could provide the necessary interrupts.

As a European resident, I now qualified for access to telescopes at the European Southern Observatory (ESO) in Chile. We applied for time on the 3.6-m telescope, the largest at ESO and the only one likely to provide adequate signal strength. We were granted six nights in April 1990 – five years after we had started the project! The measurements were successful, and after another year of analysis, we could report that the seismic signals were precisely what the theoretical models had predicted, and not what the French had reported. On the one hand, this was disappointing. A discrepancy with theory is always more interesting than agreement. On the other hand, it was deeply satisfying: an engineering challenge met and a difficult measurement successfully performed.

Unfortunately, our stellar seismometer was not sensitive enough to use on more than a few other very bright stars. In addition, the physics community began to suggest that the solar 'neutrino problem' might be due to new neutrino physics, namely that neutrinos can change their type as they travel from the Sun to the Earth. I decided it would take more resources than I could likely marshal to continue in the field of stellar seismology, so I decided to leave it to others.

The field did in fact begin to blossom some while thereafter. Improved seismometers were eventually developed, and a decade after our measurement, others were able to verify our numbers for Alpha Centauri A. As satellite observatories capable of even better measurements have been launched, the field has become a standard observational technique for the study of the internal structures and evolutionary development of

stars. At the end of the 1990s, the question of interest to me personally was resolved: It was indeed proven that neutrino physics had to be modified. The nature of the new physics was elucidated, and the measured flux of neutrinos from the Sun was thereby explained.

While managing our instrumentation program for La Palma as well as designing and building the stellar seismometer, I could not resist the échelle spectrograph I had seen at the 3.6-m ESO telescope. I wondered, in particular, whether it would allow one to measure the abundances of a radioactive element in stellar atmospheres, and thereby construct a clock for galaxy evolution that would be independent of theoretical modeling. It seemed to me that the element Thorium would be a good candidate. It has a half-life of 14 billion years, roughly the estimated age of the Universe; half of any Thorium produced early in the Universe would have decayed by now, while any recently created Thorium would still be present. So if element production followed from star formation, the rate of which was thought to have been roughly constant in our Milky Way Galaxy over its lifetime, young stars should show more Thorium, relative to stable elements, than old stars, and the amount would be an indication of the total age of the Galaxy. Leading theorists were suggesting that the oldest stars are over 16 billion years old, so I felt the effect should at least in principle be readily measurable.

The ESO échelle spectrograph turned out to have just enough spectral resolution to allow measurement of the strongest line of Thorium in a reasonable sample of stars. Several trips to Chile provided excellent data on twenty stars having a wide range of ages. The abundance of Thorium relative to other elements seemed not to vary with age, a result consistent with the idea that essentially all nucleosynthesis occurred very early. But in this case the age of the Galaxy would have to be substantially younger than the theoretical stellar evolution

models predicted for the ages of the oldest stars. I suggested that the data argued for a Milky Way age that couldn't be much greater than about 11 billion years, irrespective of the history of element synthesis.

Published in *Nature*, this was an absolutely delicious result, that was taken up in the popular press world-wide. On the other hand, it did involve a long chain of argument and assumption, so of course some astronomers and physicists attacked it (in my view, mostly without justification). Indeed, in short order the stellar evolution theorists revised their ages for the oldest stars downwards, in part because this would also bring them into consistency with new measurements just appearing of the Hubble constant (the inverse of which, at 13.7 billion years, gave an age for the Universe, which must be greater than the age of the Galaxy). In any case, I have the satisfaction that this paper created a new industry for astronomical spectroscopists, the study of long lived radioactive species in stars. The most recent observational results, I am pleased to report, give an upper age of the disk of the Milky Way, where most of the stars I could observe are found, of 8.8 ± 1.7 billion years, which is quite satisfactorily close to my much earlier result.

For both the seismological and radioactive chronological work, I was to receive the Wubbo Ockels Prize for innovative science. This prize was awarded every two years by the city of Groningen with Wubbo as patron. Essentially unknown outside the Netherlands, he was the first Dutch astronaut and famous among budding young Dutch scientists. I would keep in touch with him on and off, and enjoy his company at various times, until he passed away in 2014.

As my reputation as a scientist grew, I was asked to become involved in a number of international projects. I joined a proposal to build an improved, second generation imaging camera for the Hubble Space Tele-

scope, and another to help define a space mission on the American Space Shuttle for ultraviolet astronomy. More fitting, however, was an invitation to chair a committee to help define the scientific program for a planned European Very Large Telescope, an instrument that aimed to be at least ten times as powerful as any existing telescope. In the course of that work, I became acquainted with a large cross section of the European astronomical community, and I got to spend time, at ESO's expense, in the major European cities – from Munich, Venice, and Prague, to Paris, London and Copenhagen. Europe is a continent easy to enjoy.

But more immediately important, as I studied the designs of instruments for the next generation of very large telescopes, it became clear that at the highest spectral resolutions, such as those required for the Thorium observations, existing optical designs for spectrographs could not be coupled efficiently to the main telescope. That is, the net signal would not be much greater than on existing, much smaller telescopes, even though the telescope gathered ten times more light. A new optical design would have to be invented. Thus was born the Holographic Heterodyned Spectrometer (HHS) project.

The idea behind the HHS was to adapt for astronomical purposes an interferometer design used in optical test laboratories. The idea was novel enough that we had no difficulty obtaining funding, and ESO even provided an optical engineer for detailed design and construction. We demonstrated that the design not only could be coupled efficiently to very large telescopes, but also that it would be much less expensive to build than existing designs. Unfortunately, the amount of spectrum one could record in a single integration was limited by the width of the CCD detector. ESO policy committees concluded that there would likely be more science produced at lower resolution with large instantaneous spec-

tral coverage, and that this limitation to the HHS made it hard to justify the investment in a fully functional and automated HHS for the European large telescope. It was an idea ahead of its time, I like to believe, and I imagine it will resurface at some future date. For me, it was great fun to explore this instrumental possibility.

While my career was in the ascendancy, Phillipa experienced a much less satisfying time. Stuck at home without extended family or readily organized child-care, in a new country with a different language – this being before internet and social media – she could not help but feel isolated and alone. She did take an immersive language course, and her parents from Australia did come visit for several months (it was summer, but they were constantly cold and would never come to visit again). As CT became old enough to attend pre-school, she discovered that her training in Tucson for teaching children with learning disabilities would not be recognized in the Dutch system, with as consequence that she would have to re-train if she wanted a job.

She became actively involved in the elementary school across the street. She volunteered as a part-time reading mother (leesmoeder), to assist the teacher in helping the pupils learn to read independently. She lobbied for the school to allow supervised play during the lunch period, so children, whose parents wanted them to, could stay over. She did re-train and gain a certificate that let her work part-time at a rehabilitation center (Beatrixoord) helping handicapped and chronically ill people learn to function as much as possible in normal society. This experience, as well as the unavoidable commitment of time to our children, convinced her that she wanted to undertake formal study in the Faculty of Psychology at the Groningen University.

To qualify for the psychology program in Groningen, she first had to complete a number of prerequisite lecture courses. Going back to university study

after so many years was a struggle, but she stuck with it. In her case, matters were complicated not only by young children and a husband who was away a lot, but also by the assigned study material, which was often in a foreign language: German and French as well as English and Dutch. Nevertheless, on 30 August 1991, she graduated *cum laude* in Psychology, making me very proud of her – really, in the circumstances an extraordinary achievement. She impressed her supervisors to the extent that she was offered a graduate scholarship to pursue a PhD. She hesitated briefly, realizing the commitment it would mean, but of course in the end decided to take up the opportunity.

By this time, I was feeling restless, limited in what I thought I could accomplish in the university environment. It seemed like a good time to consider moving to another job. However, given Phillipa's new opportunity, and Jeremy and CT's integration in the local school system, we wouldn't want to leave the Groningen area.

Fate intervened once again, when the Netherlands Foundation for Radio Astronomy in the village of Dwingeloo, an hour south of Groningen by car, advertised for a new Director. Given the new investments in optical astronomy, this laboratory of about a hundred technical staff now also was looking to increase its optical activities. Indeed, their senior management had been involved in the oversight of my program in Roden. I was impressed with several of the engineers in Dwingeloo, and thought I could work well with them. I imagined I might be considered for the job, and I applied. In the Dutch system this meant a nine-month wait while the various committees met and considered all the applicants and their referee reports.

In the meantime, I was invited to spend time at the South African Astronomical Observatory in Cape Town. This sounded interesting, both because apartheid

was still very much in force in South Africa, thus giving me a chance to experience life under such a regime, and because visits to the animal parks would be an adventure. While Phillipa and Jeremy were committed to their on-going activities, Christo was in his last year but one at elementary school and not enjoying it much, so we arranged for him to accompany me. The elementary school in Roden was supportive and provided a program of lessons to take with us.

We spent three months together in Cape Town. We would work in the morning, he on schoolwork, I on various research projects. In the afternoons we had adventures together. We visited the beach, Table Mountain, local schools (many of which in Cape Town at the time were already integrated), and on occasion went farther afield to the animal parks, and to historical sites relating to the Boer War and Zulu uprising. My favorite recollections are of a hot air balloon flight along the Paarl River valley, and of watching Christo ride an ostrich.

I was moved by some of the Afrikaner memorials. Indeed, I was surprised to find I identified more with the Afrikaner history and culture in the country than with the British involvement. I suppose this had something to do with the Afrikaners being pioneers struggling against nature, indigenous peoples, and British oppression, which in some ways is very parallel to the American story.

On returning home, I learned I would be appointed Director in Dwingeloo. A new phase of my life was about to begin. I was well aware that my days as a researcher were now over, but I hoped I could successfully contribute to science through organization and management.

Historical remarks

The Dutch emerged from World War II with their demographics largely intact. In particular, the society remained segmented into four main social constructs, referred to as pillars (*zuilen*). The defining precepts were Protestantism, Catholicism, socialism, and liberal conservatism. Individual participation in trade unions, schools, universities, political parties and churches, but also preference for newspapers, broadcasters, and even retail shopping, was closely aligned with one of these pillars. The situation, together with the long struggle against the North Sea, has led to a deep-seated conviction that cooperation and pragmatism are the best ways to achieve societal goals. This attitude is also built into the electoral system. Proportional representation and a diversity of political parties lead essentially always to coalition government. Electoral candidates are, therefore, connected to political parties but not to geographical districts. The result in practice is generally a focus on national interest rather than on local electoral advantage.

Following World War II, the government played an important role in the nation's economy, managing inflation, monitoring and stimulating business activity, financing infrastructure, and maintaining strong social welfare programs. Between 1950 and 1973, economic productivity grew consistently, and full employment was maintained. Wealth inequality was minimized. Social pragmatism led to a tolerance of soft drugs and prostitution.

From the late 1960s the country saw increased social mobility, growing secularization, and significant weakening (although not elimination) of pillarization. Women began to enter the work force.

Pillarization has left an interesting feature in Dutch society. A strong feeling of national identity and of pride in being Dutch is largely absent. The Dutch have learned to live with their neighbors, and accept diversity in culture, religion and ethnicity. Such tolerance has historical roots stretching back to the 17th century Golden Age, but remains a defining characteristic of the society.

By the early 1970s, the US had overreached and overspent, and could no longer back the US dollar with gold. The gold standard was abandoned and currencies left to float. Nations relying on trade, such as the Dutch, suffered, and growth slowed across Europe. The sector least affected was North Sea gas and oil, which began to dominate the Dutch economy. The sector drew labor and investment from other sectors, causing many industries to close and leading ultimately to a recession. The government intervened in the early 1980s, privatizing industries, eliminating government debt, and stimulating economic competition. Policies aimed at stabilizing wage growth, stimulating business, and ensuring attention to infrastructure were agreed. The concept of the 'knowledge infrastructure' was introduced to promote innovation.

Chapter 10
Astronomy through the clouds

You've got to go out on a limb sometimes, because that's where the fruit is.

– Will Rogers

Weather in the Netherlands is sometimes best described as wet air. Even when it is not actually raining, you still seem to get wet. From my own experience, it is normally cloudy and raining or threatening to rain in the country. Any sensible person will conclude it is a terrible place to do astronomy.

But the Dutch are a clever lot, and they realized that even in the rain all those German radar stations along the coast during World War II worked fine. So, after the War, one of these antennas was pointed at the sky to see what one could detect. A prediction by Henk van de Hulst, made in Leiden during the War, that one should see lots of cold hydrogen, was immediately borne out. Exploration of the cosmos with radio waves would be a new growth science. And clearly, given the weather in northern Europe, radio astronomy and the Dutch were made for each other.

The Netherlands Foundation for Radio Astronomy (NFRA) was set up to carry a national technology program for developing the new field. In this model, most scientific research should take place at Dutch universities, with NFRA enabling that research through a program of technological and operational support. There would of course be an intimate collaboration between NFRA and the university groups.

To minimize interference from man-made radio signals, an NFRA Institute with laboratories and telescopes was created and located as far from cities as possible, in the forest near the village of Dwingeloo in the Province of Drenthe, some 40 min by car across the countryside from Roden. A new, larger antenna, 25 m across, was built to map hydrogen in the Milky Way Galaxy. And in 1970, an array of twelve (later 14) 25 m antennas was built in the forest near the village of Westerbork, located 20 km from Dwingeloo. This facility pretty much dominated the science of radio astronomy for ten years. The engineers at NFRA had turned Dutch astronomy into a powerhouse of science using radio frequency technologies.

By the late 1980s, however, the Americans had built a bigger radio telescope and were starting to make all the best new discoveries. Senior Dutch university opinion leaders felt that the era of radio astronomy had passed, that the future would lie in optical and infrared astronomy. A decision was made to partner with the British to build new optical and infrared telescopes on La Palma in the Canary Islands, and a new far-IR and submm-wave radio antenna on Mauna Kea in Hawaii. NFRA was called upon to help develop the telescopes and relevant instrumentation for both.

To effect such a radical change in technological orientation is not a trivial exercise. Many at NFRA were not happy with the decision, especially because the Dutch were only 20% partners in the UK/NL collabora-

tion and could influence the scientific and technical programs only marginally. They felt the collaboration would turn out to be a recipe for making Dutch astronomy a second rate scientific community. Some of the best engineers left the organization, including John O'Sullivan, who while at NFRA had developed the algorithmic basis (together with Jan Noordam and Johan Hamaker) that would later be adapted and implemented around the world as the WiFi wireless local area network standard.

As a result, when I arrived as the new Director in late summer 1991, I found an organization in crisis. The Foundation's Board of Governors was comprised of university academics having little knowledge of, or affinity with, engineering and technology, the core activities of the NFRA Institute. And to make matters worse, it was very much a hands-on Board, trying to be involved in steering the day-to-day operations. Local management consisted of a committee of three engineer-astronomers, who couldn't agree on what to do. The general atmosphere was one of gloom, and certainly not the innovative culture with a can-do attitude that is necessary for such an organization to be successful.

Luckily for me, the parent organization – the Netherlands Organization for Scientific Research (NWO), a government body formally the employer of the staff at NFRA – had already in 1990 hired a management consultancy to advise on how the Foundation should be reorganized so it would function better. The advice was clear: (i) hire a single Director to carry full responsibility for implementing the program; (ii) have the Board set policy and not try to manage in detail; and (iii) restructure to foster internal communication and minimize the size of middle-management. I was happy with these recommendations, and NWO agreed to pay the attendant restructuring costs. In the end, the reorganization took almost a year to implement.

It was a baptism of fire. I had to let people go, negotiate with staff and the unions (both internal and external), and learn the details of Dutch employment law. While the internal engineering processes were more advanced than at the university, the best tools were not available and there was no culture of striving to stay at the forefront of technology. It became obvious that, while having ultimate responsibility for the organization could be intoxicating, obtaining and exercising the authority necessary to carry out that responsibility would often be a hard slog and no fun at all. As the organization grew and its program evolved, I would have to carry out similar restructurings two more times, but neither would be as stressful as this first one.

I had no difficulty convincing the Board that the manpower available was insufficient both to run and continue to enhance the radio observatory as well as to help develop the observatories on La Palma and Hawaii. That the team in Roden should be transferred to NFRA was quickly agreed.

But NWO also decided to change the organization's name to ASTRON, and at the same time to transfer its university grants activities to NFRA. At first I had no problem with the latter seemingly innocuous change: it appeared to put me in charge of all of Dutch astronomy! But I quickly found it to be a major headache. The university academics on the ASTRON Board now saw an opportunity to use part of the previous NFRA budget, allocated nominally to technology development, observatory operations, and the UK/NL collaboration, to increase funding for grad students and postdocs at their institutions. University research always seemed to require funding urgently, while the engineering projects typically took many years to complete, so were not seen as urgent.

On the other hand, NWO had contracted with the UK research council for work to support the UK/NL col-

laboration on La Palma and Hawaii. One would think this would provide a safeguard of the required manpower. These latter efforts were unfortunately also suboptimally resourced in Dwingeloo, so the tension between the university groups and ASTRON over funding became almost tangible.

At the same time, the university community was divided about the future of Dutch astronomy, and therefore also about the future program at ASTRON. While everyone accepted that we were committed to the UK/NL collaboration, only about a third really wanted to throw all available resources into optical astronomy. Another third wanted to continue to focus on radio astronomy, and on refurbishing and enhancing the Westerbork radio telescope. And a very vocal third was split between those wanting to join an American project to build a millimeter wave telescope, and those who wanted more investment in university staffing for theoretical studies.

That the community was fractious is an understatement. As the new Director in charge of 'everything' I was lobbied and pressured mercilessly. All one could do in the situation was to ensure that the community split into committees and enter into a period of intense deliberation, out of which should come a long term plan for the future of the community and of ASTRON. The process took well over a year, with many, many difficult meetings. But, by the end of 1993, a strategic vision for the coming decade had been formulated by the astronomical community. It was termed a 'vision' because even after all the meetings, the details remained to be filled in.

At the center of the vision was the idea that ASTRON should start a project to build a large new research infrastructure, when the first phase of the UK/NL cooperative agreement would terminate in 1997. This new project should be a choice between (i) partici-

pation at a 50% level in a large new international optical-infrared telescope; (ii) becoming a driving partner in an international effort to develop a new radio telescope, which should have a total signal collecting area of a million square meters – ultimately to be called the Square Kilometre Array (SKA); or (iii) morphing into an expertise center for astronomical interferometry, contributing to and helping define national and international projects in optical interferometry, in mm-wave interferometry, and in radio astronomy (in particular, by extending the Westerbork antenna array, thereby giving it a new lease on life).

The ASTRON Board acknowledged this vision, then decided each option was too broad and too diverse, given the resources likely to be available. The Board noted that the European Southern Observatory already had plans to build a very large optical telescope in Chile; Dutch astronomers' access at the 6% level would likely be guaranteed, because the Dutch contribution to the ESO budget came from the Ministry of Foreign Affairs and enjoyed long term stability. So ASTRON should focus on developing the scientific and technological cases, on the one hand for SKA, and on the other for participation in an international large mm-wave telescope.

I could live with this policy. Of the large projects considered, the square kilometer radio telescope was to my thinking the most exciting, because no one else in the world was actively developing the technologies required, and these were technology areas in which ASTRON already had great expertise. Also, the science made possible would be absolutely fundamental to understanding the formation of galaxies in the early Universe (this is why it had to be a million square meters rather than some smaller size). And of course, being largely insensitive to the weather, it might just be possible to have the thing built in Europe rather than in Chile or the USA.

The mm-wave telescope was interesting, not least because the European Space Agency had just approved a satellite mission having submm-wave instrumentation. So the science made possible at these wavelengths would be developed further in the coming years at European level. ASTRON's sister institute for space research, SRON, would develop one of the main instruments and would therefore be well funded to become expert in the relevant technologies – hence ASTRON probably would not have to do so too. We could legitimately play a minor role in mm-wave astronomy and still satisfy the policy goals.

Finally, although my field of expertise, optical astronomy, would not be the central focus at ASTRON, optical astronomy's future in the Netherlands would be tied to ESO, which as a treaty-based international organization does not suffer the peaks and troughs of funding that national projects tend to experience. We in management could plan to build capability slowly and be fairly certain we would be able to participate in scientifically important instrumentation at ESO. In the circumstances, this was an excellent outcome, even though we initially would not be major players in my field of expertise.

Not everyone was happy with ASTRON's new plans, of course. But to the community's everlasting credit, they kept solidarity in interactions with government. This feature of the astronomical community is not generally practiced by other sciences, and their researchers as a result have done much less well in securing government finance over the years.

Now all we at the ASTRON Institute had to do was implement these policy decisions.

Right away, a distraction raised its head. For many years, European radio astronomers had worked together, periodically synchronously recording the signals of their radio telescopes, later on in a computer to

form a telescope the size of Europe. Of course, the signal collecting area was much less than that of a telescope of this size, but the final sharpness of the images was nearly as good. The interested Dutch astronomers proposed that a formal European institute be set up at ASTRON in Dwingeloo to operate this occasional telescope and provide users with fully calibrated and reduced images, which would be the highest resolution images of the sky at any wavelength of light.

The idea was that an institute recognized by six or eight European research councils might grow into a treaty-based organization like ESO, and enjoy the stability of finance that ESO has.

The ASTRON Board was decidedly not positive, very concerned that there would be initial agreement and finance among the international partners, then one or more would pull out, leaving ASTRON to deal with the shortfalls. However, I saw a new European center at ASTRON as a foundation upon which we could build a reputation as an international leader, resulting possibly in a central role in the planned giant international radio telescope, SKA. Besides, the European colleagues voted me chairman of the Board of Directors of the European network of radio observatories, so I felt obliged in any case to pursue the matter vigorously.

Unconvinced, the ASTRON Board reluctantly accepted my assurances that we could deal with any problems arising, and agreed to have ASTRON host this new institute for Very Long Baseline Interferometry (VLBI). The institute would be called the Joint Institute for VLBI in Europe – JIVE, a terrible name I thought, but the astronomers involved liked it, so it stuck. At least it was a name that people could remember.

It took over a year of focused lobby (while the restructuring and community discussions were under way) to get the funding arranged. But JIVE did come into existence at the end of 1993, with an astronomer at AS-

TRON, Richard Schilizzi, as its first Director. Rightly so, he and the VLBI astronomers took the credit in public for its creation, but I can fairly say I played a crucial role in the decision-making – at ASTRON, at the Dutch research council NWO, and at the relevant Dutch government department.

JIVE has now existed and successfully fulfilled its mission for over 20 years. We had to re-compete for funds every five years at all the participating research councils, but never suffered rejection. Perhaps as important, it became a well-regarded success story in Brussels, eventually gaining both funds from and influence with the European Commission. In particular, it convinced the Commission that European radio astronomers could successfully collaborate in developing the Square Kilometre Array, thereby smoothing the way to European financing of the SKA technology development program, much of which ended up taking place in Dwingeloo.

At the same time, we started reaching out to colleagues in other countries about their potential interest in the SKA. In 1993, Dwingeloo astronomer Robert Braun organized a working group under the auspices of the International Union for Radio Science (URSI). Radio astronomers from Australia, Canada, China, France, Germany, India, the Netherlands, Russia, UK, and USA were represented. The first meetings generated sufficient enthusiasm to hold a special session at the URSI General Assembly in Lille in 1996, and to organize a Memorandum of Understanding among the participating astronomical institutes, which could be presented to governments in support of funding requests. Serious R&D began to be carried out in Australia, Canada, China, India and the Netherlands.

Now, even a quick back-of-the-envelope calculation shows that conventional radio telescope designs cannot be scaled up to a square kilometer collecting area

for an affordable price. A new design paradigm is required. The basic problem is that conventional radio telescopes are almost all parabolic dishes made of steel, and the price of steel shows no tendency to decrease with time. We wrestled with this fact for some months. I felt my background as an optical astronomer was a serious disadvantage now; I was clearly out of my depth. Most of our academics assumed it wasn't their problem.

Then Jan Noordam in Dwingleoo started hammering at me at least once a day with his idea that it should be possible to design a flat panel antenna that would absorb the incoming radio signals. Arnold van Ardenne, head of the technical lab in Dwingeloo, agreed that this should be possible by employing phased array technologies, like those in phased array radars. The earliest radio telescopes had been arrays of simple dipole antennas, but they worked at low radio frequencies and had been abandoned because the Earth's ionosphere seriously distorts signals at these frequencies.

Jaap Bregman now played the definitive role in setting our future approach. He pointed out that by going to arrays of large numbers of simple dipole antennas, then combining the signals digitally in computers, one would be moving onto a cost-curve dominated by electronics rather than by steel. Moore's law would come into play and such designs would become cheaper with time. For SKA this would be ideal, because the number of dipoles is least at low frequencies, where signals from the early Universe are expected to be found. And, he pointed out, one can copy the radio signals as many times as needed without increasing the noise (which is very different from the situation with optical signals), so one can make as many digital telescopes in software as one desires from the same antenna signals. By having everything in digital form, it should also be possible to remove the ionospheric distortions that had plagued earlier low frequency telescopes, thereby allowing investi-

gation of an essentially unexplored part of the radio spectrum. I was sold. This would be our R&D focus for the SKA. Arnold van Ardenne set about giving form to the effort, which would occupy him and the lab for the rest of my tenure as Director and beyond.

While I was flat out with restructuring the Institute, doing science politics, helping set up an R&D program for SKA, and getting JIVE off the ground, Phillipa was both managing the home front and getting on with her dissertation research. We decided life was a bit stressful at the moment and that we both needed a break. We made plans to spend the (northern) summer vacation together in Australia, away from all the immediate causes of the stress.

Phillipa and Christo were to spend their time down under visiting with Nanna and Poppa Newton at their home outside Brisbane. For Jeremy, we saw that he was interested in science and math, but thought maybe he should also see whether the process of doing research would be found enjoyable. So he and I had applied to the *Earthwatch* organization, were accepted and assigned to a research team studying kangaroos and yellow-footed rock wallabies in outback Queensland.

He and I travelled to the town of Blackall on a long-distance bus, one that stopped at every small town on the route to deliver and pick up the mail. What I most remember was the plethora of kangaroos. They were all over the place, and every minute or two during the twilight hours the bus would smack into one on the road with a loud thump. Road kill was everywhere.

We joined the research team at the Idalia National Park in central Queensland, camping out on a nearby cattle station an hour's drive from Blackall. Nights, we stunned kangaroos and the wallabies with spotlights and radio-collared them, then took turns radio-tracking them on the following days. We also did 300 m long trans-sects to establish the vegetation in the areas

where they were feeding, logging our observations every few millimeters (yes, millimeters!).

Interesting experiences included a visit by neighbors from a nearby station, who really did fly in just for coffee one morning in their light plane. Then Jeremy discovered a very young joey, abandoned by its mother, and brought it back to camp; it was heart wrenching when the team leader decided to put it down. Big red kangaroos would hop along at 40 km/h following our vehicle – spectacularly beautiful animals, they were. It rained and we were isolated for several days until the (unsealed dirt) roads to and from the station dried out. I think Jeremy enjoyed the overall experience. I know I did. Afterward, we also visited with the grandparents.

Back in Groningen, Phillipa's research gathered momentum. She set about measuring in a clever way the quality of attachment of premature infants to their mothers, as a function of the mothers' sensitivity to and rigidity of interaction with the infants. It was a work of high scholarly level, and got published at the end of 1993 in a prestigious Swedish journal. It convinced her she should devote the rest of her dissertation research to the psychological development of pre-term infants. In the process, she quickly became an acknowledged expert in the field of Developmental Psychology. She would receive prestigious awards for her work and be asked to give reviews of the subject at international meetings.

As 1994 dawned, I was frustrated by the poor state of our institute buildings in Dwingeloo. There are administrative advantages to being far away from one's parent organization, NWO being located two hours drive away in The Hague. But this was a time when I felt we required their attention to the shabby state of our offices and labs. NWO pleaded poverty and did not wish to help out. I decided to do one of those things that one really shouldn't do, but at the time seemed necessary: I requested the government's building inspectorate to exam-

ine our buildings. They duly declared them unsafe for habitation, and required NWO to act. In the end, there was nothing for it but to demolish the older wings and construct a whole new building. In the process we convinced NWO that we needed new manufacturing and test facilities to do the agreed R&D for SKA, which would put us well ahead of any international competition for such work. Together with the architect we realized a design that would also promote communication and collaboration between academic, technical and administrative staff. This project was fun, and the completed building would serve the Institute well for many years.

We also underwent one of those periodic reviews that are the bane of publicly funded organizations. Later on, we would have to be evaluated separately by provincial, national, European and fully international panels of experts, all at different times, but for the moment we only suffered the one review, which was sponsored by the research council. These continual evaluations were an enormous time-sink. On the other hand, they consistently produced positive, even enthusiastic reports, so I guess we got very good at preparing for them. It is, however, unclear whether they ever helped keep our base funding level from being cut whenever money at NWO got tight, which happened every few years.

The international panel of 1994 were enthusiastic over refurbishing the Westerbork telescope and over the projected R&D for SKA, and they endorsed the effort to join an international mm-wave telescope project, all conclusions that made my life easier: I could now safely minimize activities that did not directly support these programs.

We presented our ideas on the advantages in cost and performance of phased array panels for SKA at the URSI General Assembly in Lille. The Australians at CSIRO, in particular, were interested, and we held an

impromptu ASTRON-CSIRO workshop in Delft following the URSI-GA. I decided as a result of this workshop that I really needed to understand the science that could be done with the software telescope design for SKA.

After several months of study, it became clear to me that far and away the most important observations would be of the first luminous objects that formed just after the Big Bang. No one knew what these objects might be – black holes, massive stars, imploding dark matter. There had been theoretical predictions fifteen years previously, in both the Soviet Union and in the UK, that they might best be detected at low radio frequencies (that is, at wavelengths near 2 meters). The phased array design would be ideal for such observations.

That winter I became excited enough to personally make a lecture tour, presenting the idea that perhaps the most important science to be done by SKA would be to detect the first structures forming in the early Universe, and to follow their evolution into stars and galaxies over cosmic time. Of course, I also promoted our work in Dwingeloo on phased array designs, saying they would be the most cost effective way to build the telescope.

Academics can be catty at times. At most of the universities my talk was received courteously and with interest. In early December 1996 in Leiden, however, I was roundly attacked and criticized for not knowing what I was talking about. The radio signal from the early Universe would in principle be undetectable, and in any case, the phased array design for SKA had fundamental flaws – its noise performance, in particular, would be so poor as to make it completely uninteresting for astronomy.

This was not good. I suppose my background as an optical astronomer led some of those present to feel free to rubbish my story. If their critique became wide-

spread in the community, we would have serious trouble selling the innovative phased array design. I knew I was right, but being right plays little role in politics, be they scientific or any other sort.

It turned out that fortune was on my side. George Miley, the pre-eminent radio astronomer in Leiden at the time, had not attended my talk. But some while thereafter he became interested in low frequency radio astronomy for other reasons – mainly to detect powerful radio galaxies at large distances. He was skeptical about the feasibility of the SKA project and formally proposed that ASTRON build on our R&D on phased array antennas actually to construct a working low frequency radio telescope rather inexpensively.

He organized a small international gathering in Leiden in June 1997, and did an excellent job promoting his idea for a phased array telescope that could do his science. He suggested to call it a name proposed by ASTRON's Ger de Bruyn, LOFAR (for LOw Frequency ARray), which was duly adopted by the community from then on.

The phased array concept was back in favor. The only difficulty was that Miley started telling anyone who would listen that the telescope would be so cheap to build that the Dutch community could do it all by itself. He talked about a total, all-up cost of 20 million guilders (roughly 10 million euros), an estimate that would turn out to be fully ten times too low. I could see right away that his cost estimate would come back to haunt us at some point. But as a respected 'expert' he was generally believed, and it did help to anchor the project in the community's thinking. He subsequently gladly assumed the mantle of the 'Father of LOFAR,' which I applauded because it ensured acceptance of the phased array concept by the Dutch university community.

LOFAR would not be SKA but it could be seen as a prototype or pathfinder for SKA, a vehicle for explor-

ing the technological options for SKA. The main challenge would be to obtain adequate finance, as we could not hope to do the work on our basic budget, Miley's claims notwithstanding. I felt an important element of the campaign for finance, both for LOFAR and ultimately for SKA, would be to get the projects onto the agenda of governments and their research councils in many if not most of the rich industrialized countries.

Personal lobby of foreign governments and research councils by myself or other astronomers would not be a workable approach, I felt, but the Dutch are enthusiastic supporters of international cooperation, and were involved in the OECD Mega-Science Forum, even providing its chairman, one Peter Tindemans. This body had come into being following the debacle surrounding cancellation of the US Superconducting Super Collider for high energy physics. It brought together ministry level representatives of governments to exchange information on and plans for future large scientific facilities.

Tindemans thought the SKA might fit well into its deliberations, and invited me to attend a meeting in Paris in January 1997. The Forum accepted our proposal to set up a Working Group on Radio Astronomy, aimed at exchanging information on plans for the next generation of radio telescopes, with me as chairman. We met three times, twice at the OECD in Paris and once in Washington DC at the White House. Some 35 delegates from 17 countries attended these meetings. The final report in November 1998 presented an inventory of radio astronomical activities around the world, and identified telecommunications satellites as a major threat to radio astronomy – because they broadcast strong signals down from the sky that overwhelm naturally occurring signals from the distant Universe. We recommended that the Mega-Science Forum bring governments, astronomers and the telecom industry together to formulate solutions – the most likely being to designate a part

of Western Australia as the best place in the world to establish a protected, radio quiet reserve. This led to a follow-on OECD Task Force on astronomy and the radio spectrum, which reported in 2004.

In hindsight, I think I can say that this OECD exercise was useful for astronomers and brought our needs to the attention of many governments. But it must also be said it showed that the American science community, which would have to give SKA a high priority if funding would be forthcoming in the US, had essentially no influence within the highly politicized decision-making processes of the US government whenever major industries like telecoms are also part of the mix.

I learned a lot about international organizations and about cooperation with the US during these years. I learned, for example, that the US government is amazingly feudal in character, full of bureaucratic fiefdoms, often with overlapping missions, that fight among themselves and make decision-making difficult. During much of this period, the office of President's Science Advisor was vacant, and in practice there was essentially no one able to engage with us with any effectiveness. It also became increasingly evident that the US often participates in international gatherings with the sole purpose of ensuring that nothing gets accomplished. That SKA was not yet a priority in the US, meant that US delegates worked visibly to ensure other countries would be discouraged from moving the project forward. Put another way, unless the President himself or an influential congressman wants something, the way to accomplish things in America is from the bottom up. Unfortunately, the bottom-up model, when commercial interests are in the balance, allows science hardly a look in.

An important step in the process of selling our ideas and plans specifically to the Dutch government, and indeed to the wider Dutch public, took place on 6 May 1997. As the new building in Dwingeloo ap-

proached completion, we invited Queen Beatrix formally to open it. To my surprise, she accepted!

She arrived by helicopter, landing on the heather field behind the Institute. As formally responsible for the site, I joined the Queen's Commissioner for Drenthe, to greet and escort her into the building, where various dignitaries as well as staff and Board members waited. The Minister for Education, Culture and Science attended, as did the Mayor of Dwingeloo and Harry Mulisch, a Dutch author famous for his book of fiction, *The Discovery of Heaven*, in which our Institute figures prominently. The chairman of NWO put in an appearance, of course, but also Ron Ekers from CSIRO in Australia, who in his speech sang the praises of our work on the SKA, and Frank Drake from the SETI Institute in California, who discussed the prospects for detecting other civilizations in the Galaxy with SKA. After the speeches, I got to give her a guided tour of our new facilities, which I must say, gave the impression we knew what we were doing on our road to the SKA. The event was covered on the national evening television news, and so the whole country got to hear about our ambitions in radio astronomy.

It is perhaps amusing to note that Her Majesty was not allowed to use our lift, because of a fear that the lift might get stuck between floors – that would be most un-royal! Neither could she enter our anechoic test chamber, but was only allowed to peer in from the door, again for fear the door might get stuck and trap her inside. Personally, she was very nervous about the microphone I was wearing as we walked around: She instructed me to be very certain to let her know when I had it turned on. Evidently, at some point in the past she made an off-the-cuff remark, only to have it reported in the press, to her great embarrassment. But overall, she was gracious and seemed genuinely interested, asking good questions. After about an hour, she hopped

back in her helicopter and headed back to her palace in The Hague, leaving us to party and network among our influential guests.

Shortly thereafter, in June 1997, Jeremy graduated from high school. He was clear he wanted to go to university. He had attended master classes in science in Amsterdam and we had visited several possible local universities together, before he decided he wanted to attend the University of Technology in Delft.

When discussing his future, it seemed likely he would choose ultimately to stay in the Netherlands. So before he got started at university, we thought it would be a good idea if he would visit the United States and my side of the family, as part of his general education. Sister Nadine was doing her doctorate at Harvard at the time, and graciously lent us the use of her Jeep, to drive leisurely from Boston to St. Louis, where we would join up again and drive together to California to see brother Eugene and his family.

The road trip let us visit any number of interesting places. We toured Boston and Marblehead, went to the antique airplane museum in Rhinebeck, New York, played softball with a colleague from Chile and his friends in Columbus, Ohio, and attended the 4th of July celebration on the Mississippi waterfront in St. Louis. The last, I must say, was impressive. St. Louis is home to military aviation manufacturing, so we were treated to a spectacular air show, reaching its climax with a low-flying performance by a B-1 bomber. As dusk descended, a fireworks show began that was extraordinarily well synchronized to *The Ride of the Valkyries* by Wagner. Finally, comedian Bill Cosby entertained the enthusiastic crowd of many thousands. Jeremy's reaction to all this I do not recall, but I enjoyed it immensely. It was all vintage Americana.

As we drove on together from St. Louis across Missouri, through Kansas, Colorado and westward,

however, I became amazed at the poverty, something I had not expected at the level we found it. Even in the 1990s, the wide gap between rich and poor was evident if only one bothered to look.

While in California, I attended a most exciting workshop, the first of three, organized by the SETI Institute in Mountain View. SETI stands for the Search for Extra-Terrestrial Intelligence, and the idea was to develop a 'roadmap' for new attempts to discovery technologically advanced civilizations elsewhere in the Galaxy. I assume I was invited because I was promoting the SKA, which would be far and away the best way to detect radio signals 'leaking' from Earth-like civilizations, should they exist around nearby stars. Jeremy attended part of the discussions, and met several leading figures in the IT world, including Greg Papadopoulos, Chief Technology Officer at Sun Microsystems, and Nathan Myhrvold, former CTO at Microsoft. Nobel Prize winner and inventor of the laser, Charles Townes, also contributed to the discussions. Again, I am unsure what Jeremy's impression was, but I was astonished and a little bit flattered to find myself in such exalted company.

Back in Dwingeloo, vacation over, it was time to begin a lobby campaign to acquire additional funding to support our R&D program. With the Americans dragging their feet on SKA, it was clear the main thrust of our R&D should be toward LOFAR, which again, could serve as a means of prototyping innovative technologies for SKA.

The lobby campaign began to occupy most of my time, and was influenced by two developments.

First, I remained of the opinion that an international dimension to the LOFAR project would be imperative. In particular, I had observed that small countries like the Netherlands had a much easier time making decisions on expensive scientific projects when the US scientific community was a partner. Presumably this

was because the decision-making process at the US National Science Foundation is generally thorough and transparent, so outcomes can be trusted to be well considered. As long as one remained within the NSF orbit, the inter-agency rivalries should not play a role. How to get the US involved in LOFAR? As fate would have it, at the annual SKA coordination meeting in Calgary, Canada, in July 1998, after we presented our ideas on the phased array paradigm and argued that much of the most important science could be done with a low frequency telescope based on this technology, colleagues from both the US Naval Research Laboratory in Washington DC, and from MIT in Cambridge, Massachusetts, approached me with great interest in joining together to develop LOFAR further. This was good, because it was the kind of bottom-up interest that the US system could handle.

The NRL group was mostly interested in studying our Milky Way Galaxy at low frequencies and was hoping to place a low frequency telescope in New Mexico. The MIT group had become interested in the early Universe but also in the outer atmosphere of the Sun. They seemed most keen on a radio quiet site in Australia, which brought the Australians on-board a short time later. This diversity of interests and goals was not the ideal starting point for a coherent project, and some of my Dutch colleagues argued against foreign involvement, but I felt the addition of international partners to the LOFAR project would be a major boost for our campaign for funding at home.

Second, ASTRON's parent organization, the research council NWO, reorganized itself. It removed the university grants activity from our work program, which I applauded wildly (if in private), but also changed our funding model. From now on, we would receive a base budget for maintaining buildings and for core staffing, but would have to compete with the universities for ad-

ditional finance to carry out projects. On the surface, this seemed a reasonable model for a research council to have, supporting its own institutes while maintaining strong university research groups. But of course, it was really meant as a way to save money while appearing to optimize its program. It quickly became evident that we could not complete already contracted instrumentation projects without going into the red.

I complained vehemently to the NWO Board chairman, Reinder van Duinen, that we could never carry out our mission of technology development for large international projects if we had to compete with the universities for finance, both because the peer review decision-making process was dominated by university colleagues, who always have short-term needs, and also because the new boundary conditions on grants did not allow full cost recovery.

Van Duinen had come to NWO from the Fokker Aircraft company and agreed immediately with me. But he said he couldn't do anything about it. We would just have to live with the situation as best we could. As a sop, he did say to me that we would be allowed to do anything we could think of to gain additional resources, the only restriction being that our actions should be legal.

This opened interesting doors. We immediately made plans to set up a commercial company to market some of our technology, and began to network into the commercial world, both to exploit our expertise with radio and signal processing technologies in support of local industry, and also to expand our contacts to include large international companies such as IBM and Lucent Technologies.

Thus began a seemingly never-ending series of organizational meetings, lobbying sessions, congresses, and technical workshops, all aimed at networking into industry and politics, ultimately to increase financial

support for our program. To be clear, these efforts were in addition to the similar meetings and workshops with our own astronomical community, both nationally and internationally, as well as on-going improvements to our internal engineering processes and operations at the radio observatory.

I owe an eternal debt of gratitude to the chairman of the ASTRON Board of Governors during this period. Ed van den Heuvel was a famous theoretical astrophysicist from Amsterdam, whose research focused on spinning neutron stars, the so-called pulsars. He had no personal affinity with our R&D program, nor any political reason to support such a radical departure from past policy, but he did, and he helped convince the rest of the Board to support the effort. I was lucky to have such a forward thinking chairman, willing to take a risk.

A new hire also helped enormously in structuring and sharing out the activities. Subsequent efforts would not have been successful without his involvement. Eugène de Geus joined ASTRON early in 1999. He was an astronomer by training, but came to us from Kluwer Academic Publishers, where he had developed an extraordinary talent for sales and finance, as well as an appreciation for how to deal effectively with commercial organizations. He took on the job of Deputy Director, quickly understood both our technologies and our financial requirements, and set about prosecuting our lobby and sales campaign efficiently and, I must say, very effectively.

His talents complemented mine and together we made a formidable lobbying and networking machine. We were also greatly helped in our campaign by a new feature of government policy. By the end of the 1990s, it had become clear that the country required substantial new investment in infrastructure – roads, railways, canals, airports, and also environmental planning. In the analysis leading up to definition of the policy, it had

been identified that investment in the 'knowledge infrastructure' would also be required if the large-scale new plans were to be efficiently and effectively implemented.

By 'knowledge infrastructure' was initially meant the training of high-class engineers and planners able to carry out such major projects. But by 2000, the concept had evolved to include the creation of new knowledge in high-tech as well as in the classical engineering fields. Astronomy, of course, would be excluded, because it was seen as a cultural pursuit and not directly relevant to economic growth. But our program of technology development for SKA and LOFAR seemed to us perhaps to qualify for funding under the new, evolved policy. We began to sell industry on the importance of the high-tech developments in Dwingeloo, and to get them involved in our program at some level. Politicians were sent the message that astronomy is a wonderful way to invest in strengthening local high-tech industry without running afoul of European Union regulations that forbid direct government support of companies. And we worked hard to build a broad base of public support, which turned out not to be difficult because the public generally is fascinated by astronomy.

At home, the other part of my life, good things were also happening. Jeremy was starting university in Delft, studying physics, and had found a room with a nice landlady near the university. Christo was finishing high school and doing well. And Phillipa was deep into her dissertation research.

As we had with Jeremy, we wanted that Christo should experience participating in a research team, again to see whether he would find the process compelling. And again, we thought it might be fun for him to go on an *Earthwatch* expedition. Together we chose a team studying mountain lions (pumas) in Idaho. We would run through the mountains after a pair of dogs, locate and tree an animal, dart it, and put on a radio collar.

Then we would track its movements, which we understood could sometimes cover hundreds of miles. It sounded like an exciting adventure as well as a chance to contribute to an interesting research project. But alas, it was not to be.

One of Christo's school friends had wanted to sit for the Dutch Chemistry Olympiad, and asked Christo to come along too. Christo qualified easily and went on also to be chosen for the International Chemistry Olympiad, to be held in Bangkok, Thailand, in July 1999, at the same time as our mountain lion plans. Thailand seemed the greater adventure, so Phillipa and I chased mountain lions and Christo went to Bangkok. His team won a bronze medal and he met young Thai people with whom he would keep in contact for many years.

The next summer, of the year 2000, saw us all decamp to Cambridge, Massachusetts, to attend the graduation of sister Nadine at Harvard University. Mother came too, in her wheelchair. It was a grand ceremony. The weather was lovely and warm, and we could enjoy Nadine's achievement as a family. Her PhD dissertation was entitled: *Teaching and nature - Middle school science teachers' relationship with nature in personal and classroom contexts*, and studied the tension high school science teachers generally feel between their personal experience of nature and the requirements of imposed curricula.

Phillipa at this time was spending her days doing her dissertation research at the University. It focused on babies with ages between 6 weeks and 6 months, and how their development is affected by premature birth. Specifically, she built an experimental setup to follow their visual gaze as stimuli appeared at different positions in their visual fields, and she followed their ability to disengage from one stimulus and move to another, as a function of age. The age at which disengagement be-

comes easy was taken as one measure of brain development.

While most psychological research involves questionnaires at one moment in time and is hardly precise, hers followed subjects over time and was strictly quantitative. The main problem encountered, other than keeping the eye tracker working, was to enlist normal babies into the sample. That is, mothers of premature babies were generally keen to join the research, hoping to hear that their child would be found to be normal, but mothers of normal babies had no motivation to participate. I may be biased, but I found it an elegant, thoroughly scholarly piece of work.

She defended her dissertation, entitled *Longitudinal studies of visual attention in infants: The early development of disengagement and inhibition of return*, in public in the Auditorium of the Groningen University on 8 January 2001. A grand party followed at a local restaurant, where friends and colleagues, according to Dutch custom, congratulated Jeremy, Christo, sister Helen from Australia, and me, as well as Phillipa herself, for her successful defense. Shortly thereafter, she won the Netherlands Association for Psychonomy Prize for best thesis in the period 1999-2001. It was a wonderful start to what would turn out to be an exceedingly eventful, and stressful, year.

Of signal importance to my life in the year, and subsequently, would be Ria Moraal. Ria came to ASTRON early in 2001 as management assistant to Eugène and me. Previously she had worked for many years as secretary to the Queens Commissioner in Drenthe, the province in which ASTRON is located. In this capacity she had built up an astonishingly broad network of acquaintances in the country's political and commercial worlds. She knew many of the personal assistants to the political elite, and quickly developed additional contacts in the ministries and industries most relevant to us. She

cultivated these contacts assiduously, in particular by inviting them once a year to a party in Dwingeloo, where Eugène and I would give presentations and a tour of our facilities, followed of course by drinks and a nice meal. As a consequence, we almost never had trouble gaining access to their bosses.

Again I found myself travelling most of the time. But now, Ria made a modicum of home life still possible. She did so by insisting on two things.

First, she and only she would manage my diary, scheduling my meetings and the like. She would act as gatekeeper, so I would not be distracted from how I was supposed to spend my day.

Second, she organized a car and chauffeur for me. Well… Now… In the world of academia, this was simply not done! But she insisted. I would be picked up from home in the morning, driven to work, then to meetings or wherever, and finally home again at the end of the day. By this time, mobile phones and laptop computers had put in an appearance, and the car became my mobile office. I could work from the moment I got picked up until I returned home, no matter where I had to be. The car she hired was a big BMW, and the chauffeur not only wore a uniform, but had trained for driving in attack situations, such as attempted assassinations. The latter was overkill, but he and Ria kept in touch all day as my schedule evolved, as meetings were delayed or inserted. The most extreme day I recall took me to Bremen, Germany, for a breakfast meeting with EADS-Astrium (Airbus Defense and Space company), then to The Hague for lunch and a meeting at a ministry, to Utrecht for consultation with a company, and back to Dwingeloo to meet with a delegation of employees, before returning home in time for a late dinner. I wrote an important policy document that day in the car as well.

Our preparations for LOFAR and our R&D for SKA were going well as the year progressed. We did

begin to experience friction with our American partners in LOFAR at the Naval Research Lab and at MIT, however. While our science goals were fairly well aligned, our engineering goals were not. Funding agencies in the US wanted to see only tried and true technologies employed, while we were convinced that our only hope for finance in the Dutch and European contexts would be to propose innovative technologies. Then, although it was never said out loud, it became clear to me that US funding policy would likely require that the US partners be leading the project. Depending on how funding became available, this could turn out to be a major problem. Nevertheless, all parties expressed the wish to continue to work together. For us, this was important, because the new subsidy program we had in mind, one for stimulating the 'knowledge infrastructure' in the country, would by design provide only half the necessary funding. The rest would have to be found from outside Dutch government sources. We needed partners with finance.

The relevant subsidy program was to run in two phases. First was an 'Expression of Interest,' from which the government's Central Plan Bureau would prepare a cost-benefit analysis. Those submissions deemed adequately economically beneficial could move to the second phase and be invited to submit a full proposal, which would be evaluated on its economic benefits, its scientific quality, and its general importance to society.

We submitted out Expression on August 30th; it was 174 pages long and included over 30 partners, both commercial and academic. I felt it was an strong Expression, in particular because there was no broad-band internet in this period, and it proposed to develop an extensive fiber optic network across the north of the country. This network would give local businesses experience with fiber optics, with massively parallel, real-time data processing and with high speed digital networking.

These were areas of technology that plausibly would become important within a decade.

Our Expression was well received and given high marks for innovation and scientific quality, but the Central Plan Bureau replied that they had no idea how to prepare a cost-benefit analysis for such investment, and therefore could not recommend the team be asked to provide a full proposal. On receiving this depressing news, I undertook a crash study of cost-benefit analyses, and found that no one anywhere knew how to quantify the benefits of the new information technologies. Evidently, there just hadn't been enough investment outside the academic sector yet to enable models of the economic effects of the internet to have been developed.

We went on the attack, all the way up to the then Minister of Education, Culture and Science, Loek Hermans, arguing that the lack of analytical capability at the CPB should not outweigh our otherwise high marks. Finally, in the last days of the year, we met success and were admitted to the second phase of the process. We would spend every spare moment during the coming year preparing the full proposal.

But I get ahead of myself. The year 2001 saw us also having to prepare for another international evaluation of our program (to occur in December). This was an important evaluation because the government, officially or unofficially, would be aware of it as we campaigned for LOFAR and SKA funding. At the same time, the number of other tasks on my plate seemed only to multiply. I was preparing a new initiative at the OECD to try to gain agreement on setting up an internationally recognized radio quiet reserve (where man-made interference would be absent and observations of the very early Universe would be possible). Furthermore, we had to make final operational preparations for the transition from the guilder to the euro, which would take place on 1 January, 2002. A visit by Crown Prince Willem Alex-

ander and his new partner, Princess Maxima, was scheduled at their request; originally set for 12 September, at the last minute it got postponed until mid-November. We were also in a tense discussion with NWO over our budget shortfall caused by their new model of financing the institute. And finally, on a personal career note, I needed to prepare for my installation as President of the European Astronomical Society, to take place on the morning of 11 September. With the benefit of hindsight and a few surviving photos, I am convinced this was the period when my hair started to go grey.

I recall 11 September vividly. Late in the afternoon, following my installation as EAS President in Munich, I was at the airport on my way home when videos of the terrorist attack on the twin towers in New York appeared on the TV monitors in the waiting area. My first reaction was that maybe this was a modern adaptation of Orson Wells' 1938 radio drama *War of the Worlds*, which was fiction but so well presented that many thought it real. A few moments later, however, as reality struck, I thought: "Well, this is the result of decades of appallingly poor foreign policy by the United States." Fourteen years on, I am still of this opinion, although now I marvel at how Osama bin Laden, for a very small investment, could cause such great damage to the society of the world's superpower, possibly even ushering it down the road from enlightened government toward police state. I wonder whether he foresaw even a tiny bit of what he was bringing to pass.

Several months later, while networking into a group of businessmen, I attended with them an informal talk by a political scientist from Amsterdam. It was a masterful overview of current United States social politics. For companies doing business with the US, his message was disturbing: George W. Bush would not be an anachronism, but was heralding a generation of ig-

norant, unpredictable, right-wing politicians. The world was going to be a less nice place, and we in Europe should prepare ourselves.

I wondered, of course, whether the situation would affect potential American involvement in SKA and LOFAR. But in the meantime, we had to prepare our proposal for LOFAR funding.

The setup of the subsidy program to be used for the project deserves a few more words of explanation. The Dutch government believed that advanced knowledge and innovation would be the key to improving the country's economic competitiveness. They therefore wished to have scientific research focus more on innovation and societal needs. The program they set up was to promote cooperation in research and development through Public-Private Partnerships involving government funded research institutes and universities. Government finance would derive from revenue from Dutch North Sea gas reserves. Earlier subsidy rounds had been top-down, while our (third) round would be bottom-up and open to all comers. It was to go by the initials ICES/KIS-3. The total budget of the program was M€ 805. ICES/KIS-3 had five thematic areas – Information and Communications Technology (ICT); High quality land use, including water, climate, geo-information & sustainability; Sustainable system innovation; Microsystem and nano-technology; Health, food, gene- and bio-technology breakthroughs (including genomics). We fit best in the ICT theme, although of course fitting what was obviously an astronomy project into even this theme was going to be a challenge. I concluded there was no other way forward, however.

The proposals were to be evaluated by three independent bodies: the Royal Netherlands Academy of Arts and Sciences (KNAW) would evaluate the scientific quality; the Netherlands Bureau for Economic Policy Analysis (at the CPB) would analyze the economic bene-

fits; and a Committee of Wise Men drawn from the wider population would advise the Cabinet of Ministers on the overall value to society. Seven ministries were involved, and one imagines they each also advised their ministers on which proposals to support in Cabinet.

Our proposal was entitled *LOFAR - ICT for Wide Area, Adaptive Sensor Networks*. The idea for calling the network a 'sensor network' had been suggested by one of Christo's co-students in Delft, Gerrit Toxopeus. Following a talk on LOFAR as a telescope, that I gave to the physics students in Delft, he put up his hand and said, "What you are talking about is a sensor network with radio antennas as sensors. Why don't you put other kinds of sensors on the network too?" That was such a good idea, and would make the proposal sound less like one for a pure astronomy project, that I immediately decided to go that route. The goals in the proposal would now be said to be: (a) to lay a fiber optic network across the north of the country, and (ii) to connect to it antennas, geophones, infrasound sensors, and various environmental sensors, and then (iii) to use this sensor network to conduct research in astrophysics, geophysics, and agriculture. I viewed the broadening of the user community as potentially decisive given the decision-making structure of the subsidy program.

The astrophysical application would dimension the data network: it required fifteen thousand antenna-sensors generating 24 Terabits/sec and a total computing capacity of 40 TeraFLOPs. This was a stretch at the time, but our contacts with IBM and other technology companies led me to believe it would be achievable. The proposal certainly would not fail on the grounds of being insufficiently innovative.

After a year of effort, we not only had a detailed architectural design and implementation plan, but were able to include financial commitments from 18 organizations, including universities, research institutes and

commercial companies. The northern Dutch provinces agreed to contribute M€ 22. We even had groups in Germany and Sweden sign on, although the American groups couldn't get their acts together and could only be named as interested and possible future partners. Our estimated total cost was M€ 220, including all manpower and overheads as well as a follow-on research program. We estimated the cost of the research infrastructure (the telescope mostly) to be M€ 113, and from ICES/KIS-3, we requested M€ 73. We didn't have quite all the required matching funds identified, but we imagined that none of the other competing proposals would at this early stage either.

The completed proposal would ultimately run to 640 pages. Recalling the previous episode at the CPB, we even did our own cost-benefit analysis, which ended up as a PhD dissertation for one of our staff, Mark Bentum, and which of course concluded that the project would be an important economic boost to the high-tech sector in the northern provinces (which had very little high-tech activity at the time).

At this juncture, I must record that a new team member made an exceptional, even crucial, contribution to the proposal and to LOFAR planning in general. Jan Reitsma had worked as a Senior Program Manager at the Fokker Space company in Leiden when we were seeking help with our planning of such a large project. He had just finished rescuing the company from bankruptcy: one of the large solar panels provided by Fokker to a communications satellite had gone bad in orbit and the company was sued to recover the losses. Jan led the negotiating team from Fokker, and while largely successful, the stress of it all had nearly killed him. He needed a new job, one that would not involve vicious fights and soul-destroying pressure; Fokker management agreed and we reached an amicable agreement for his departure to ASTRON. I am sure he found us

milquetoast in comparison to the commercial space business. The relationship clicked from the start and he remained with the LOFAR project until the telescope went into operation. Indeed, the project could not have stayed on-budget and on-time without his project management. In the ICES/KIS-3 proposal, his detailed Design, Development and Verification plan was in my view the most professional and convincing section, and much better than the equivalent sections in any of the competing ICES/KIS-3 proposals.

Before the proposal text was to be put in final form, which was my task, I felt I needed to clear my head. With a submission deadline in mid-February, early December was a good moment to take a ten-day holiday. I even planned for it by organizing another *Earthwatch* expedition with Christo. This time we would go to Peru, to join a team studying the Macaws of the Amazon jungle. We went up the Tambopata River by boat to a lodge, which was completely open to the jungle. We slept under mosquito nets and were told to keep our belongings locked while we were away, because some macaws had learned to come into the bedrooms and pick through suitcases. The research goal was to monitor the nesting behavior of macaws, both in natural tree openings and in artificial nests put out by the team. We learned how to negotiate the jungle environment, being careful, for example, not to touch tree trunks because many were infested with poisonous ants. Unofficially and in the margins of the program, we learned about the use of hallucinogenic drugs by Amazon shamans. After the program, Christo and I visited Machu Picchu and Cuzco, where we happily drank coca leaf tea to help with altitude fatigue. I think Christo enjoyed the adventure. I certainly did. And it did clear my head. I returned ready to complete the final text of the proposal, to have it ready for reproduction and submission by the deadline.

Following submission, Eugène and I continued our networking and lobbying. We understood that Cabinet would make the final decision, and what the politicians heard about the project from nominally uninvolved parties could be important. But despite all the effort that we were putting in, I became seriously worried that we might not succeed. That is, until one day as I was sitting in the train, opposite two businessmen. One turned to the other and remarked that he had recently learned of a particularly interesting project – after which he more or less described LOFAR correctly. He concluded that it was just the sort of project that the government ought to be supporting. Our networking had become extensive enough that uninvolved strangers could tell each other about our project. It was a glimmer of hope.

In the event, the Academy (KNAW) gave us the highest marks. The only potential problem was that the chairman of the evaluating panel was the prominent astronomer, Harry van der Laan, who over the years had made enemies among the scientific elite of the country. The Economic Policy Analysts (at the CPB) concluded that LOFAR was a marginal case, one they could not readily analyze; obviously they weren't convinced by our cost-benefit analysis. Then, finally, the Wise Men gave us the thumbs down – we would not be providing adequate societal value!

As the day of final reckoning in the Cabinet of Ministers approached, we heard that one of the Wise Men had strongly influenced that committee's decision. He was a person who was known to have a personal vendetta against van der Laan, and who believed that astronomy had generally received far more than its fair share of funding, largely due to behind the scenes machinations by van der Laan. Knowing Harry well, I am certain there was truth in the accusation, but the story gave us ammunition for an intense, last ditch lobbying

effort among the seven ministries involved. The situation became widely known at the top levels of the Dutch public service. Interviews with us were even cut short on occasion as officials said they were aware of the sequence of events and of our spin on the matter.

The final decision on the ICES/KIS-3 funds was scheduled for a Cabinet meeting on 28 November 2003, a Friday. I got hardly any sleep the night before. We had spent almost five years preparing for this moment, and it did not look good. It would be very unusual for Cabinet to overturn the recommendation of its primary advisory committee, the Wise Men. I asked our contacts at the Ministry of Science to let us hear the outcome as soon as it was known.

At 2 p.m., my office phone in Dwingeloo rang. It was the Minister herself. "Hello. This is Maria van der Hoeven. I am calling to let you know that the Cabinet has just decided to contribute M€ 52 to LOFAR, to be paid out in 2010. Now it is up to you to make the project a success."

My goodness! I almost fainted. I pinched myself. You can scarcely imagine the relief. But, what had happened in Cabinet? How did they arrive at M€ 52, when the proposal was for M€ 73? And why would it only be paid out in 2010, at the end of the ICES/KIS-3 program?

In the weeks following, these questions were mostly answered, unofficially of course, because Cabinet meetings are secret. Evidently, two things had happened that saved the day. First, when funding for all the 36 successful proposals had been decided, there was still M€ 52 left over, unassigned. We must have had a guardian angel in the halls of government for *that* to occur! And, Minister van der Hoeven had made an impassioned plea to her colleagues, that there was something seriously wrong in Dutch politics if a project with such wide appeal and general support in the country could not get finance. The 2010 payout date made evident we

were not formally a winning proposal, and meant we would have to borrow bridging finance, but NWO could hardly not agree to provide the loan. We had our money, or at least much of it.

The next several months saw a mad scramble to re-scope the project, to save M€ 21. Luckily, much of the infrastructural budget was for laying out fiber cables and antennas, the other sensors being relatively inexpensive, so we could just do fewer antennas over a smaller area, making LOFAR somewhat less sensitive. The challenge then lay in the financial organization: we had to ensure at least M€ 52 from other sources was contributed to match the ICES/KIS-3 grant. For this, we had been counting on the Americans and Australians as well as on local and provincial governments, on our universities, and on our business partners. Most of them did come good with the promised resources.

The main exceptions were the Americans and Australians. But to a large degree it was our own fault that they withdrew from the project. Led by George Miley in Leiden, my Dutch university colleagues told our partners at NRL, MIT and CSIRO, in no uncertain terms, that a new situation had arisen, that we had our funds and they did not have theirs, so we would not only be siting LOFAR in the Netherlands but also taking over all management of the project. They could join us or not on those terms. Such a bald negotiating position had the anticipated effect: both NRL and MIT in the US and CSIRO in Australia severed all further bands with LOFAR.

Given that their goals and boundary conditions were not perfectly aligned with ours, this was not a total disaster. But it did mean we had to try to find an additional M€ 15, being their expected financial contributions. I could not understand that Miley, nominally a responsible ASTRON Board member, was willing to throw away their M€ 15. I was certain that a gentler,

compromise-seeking approach could have kept them on-board. The situation soured my relationship with Miley from then on, and it would contribute to later problems, indeed to a rupture, that we would have with NWO.

While Jan Reitsma and ASTRON's engineers got on with the technical development and procurement activities, Eugène and I switched gears from lobby mode to finance acquisition mode, to complete the matching requirement of M€ 52.

Our first success, which was realized thanks to Peter Bennema, a land planning expert seconded from the provincial government to the project, was a deal with the local nature conservancy. For contributing M€5, they could transform the land chosen for the core cluster of antennas into a nature reserve, for which they would take over maintenance and eventually also ownership, while allowing LOFAR to operate undisturbed until its ultimate dismantling at some future date. But even with this and all the contributions from our remaining partners and from the provincial government, we were still coming up short.

Then Eugène came up with a brilliant idea. We could reclaim value added tax (VAT) on much of our procurement expenditures (at 19% a very significant sum). This we could do by setting up LOFAR as a legal limited partnership (commanditaire vennootschap). Such constructions are regularly used to obtain finance for new ships and for the making of movies. Recalling Reinder van Duinen's earlier statement that we could do anything so long as it was legal, and given our matching shortfall, I decided we would have to do this to meet our contractual obligations.

Unfortunately, the choice meant a complicated management structure would be required. First, because ASTRON had astronomy as its mission, we would in any case want to avoid any appearance of conflict-of-interest as seen by the research communities in IT, physics, geo-

physics and agriculture, as well as reassure our international partners in Germany and Sweden that internal Dutch science politics would not disadvantage them. So we brought the project under a Foundation (Stichting LOFAR), with Eugène as Director. Then we made plans to set up the limited partnership to optimize the fiscal situation, with the LOFAR Foundation as managing entity. We got at least preliminary acquiescence from the tax authorities regarding the VAT issue, subject to a demonstration during the operational phase that we were using the facility to earn at least some money. Things may have gotten complicated, but I felt they were under control.

As the implementation phase of LOFAR got under way, and the matching issue to my thinking resolved, I concluded things were going swimmingly. Prototype hardware was producing lovely results; the remaining partners were happily participating; the administering Ministry of Science was satisfied we were meeting all the boundary conditions of the grant; Joris van Enst came from the Ministry with broad expertise to oversee and coordinate the multi-disciplinary science; the local populace near the center of the antenna array was excited; and we were often in the local and national news. It was exactly the kind of project the ICES/KIS-3 program had been aiming to make possible.

Among the many sub-projects involved, one deserves particular mention: our collaboration with the IBM company.

Now, in radio telescopes of this sort, the data from all the antennas must be combined appropriately, and ideally in real time. Typically, the data volumes are huge, but the computations are simple, just multiplication-and-add, albeit an enormous number of these. The requirement is for massive input-output bandwidth, while the computations can even take place via a look-up table. Most normal applications do not require large

input-output bandwidth, so generally radio astronomers have had to design and build their own, optimized processors. I had had experience with two earlier processors, one for the Westerbork telescope and one for the European VLBI array. Each one required the design and manufacture of a custom processing chip, was initially estimated to take 3 years to complete, and ended up taking 7 years, with the attendant cost overruns. It would be a public relations disaster if LOFAR was completed but had to wait idly by for several more years until its central processor became available.

We learned that IBM Research had developed a prototype supercomputer, the BlueGene-L, that not only had much of the computing capacity to handle the volume of data LOFAR would produce, but could also ingest that data in nearly real time. We visited their lab in Yorktown Heights, New York, and found that the development team included several individuals trained as research astronomers, and who were most enthusiastic about building a special machine for LOFAR. For the project it would mean that the central processor could in principle be delivered much earlier than if we had to build one ourselves.

On 23 February 2004, the same day we signed the contract with the Ministry of Education, Culture and Science for the ICES/KIS-3 finance, we signed a contract to work together with IBM to develop the BlueGene design for use in radio astronomy. This contract subsequently led to a long-term joint R&D effort on streaming supercomputing that has continued for over a decade. In the end, our BlueGene was indeed delivered before it was required by the rest of LOFAR, and well before IBM decided to market the line commercially. In fact, I think our interest in the machine, which had been unexpected, helped IBM decide that it could be a commercially viable product. For us, the collaboration was promoted in the

press as precisely the sort of innovation the government hoped to realize with its stimulation program.

The year 2004 was a banner year in yet other regards as well. Brother Eugene emailed one day that he had jointly won the Royal Swedish Academy's Crafoord Prize, second only in prestige to their Nobel Prize. We all decamped to Stockholm on 22 September to enjoy the ceremony celebrating his work on white blood cell migration to areas of inflammation in the body. It was a posh ceremony and I was very proud of him. Nadine and Mother weren't able to attend, but at least Mother had the pleasure of learning about Eugene's fame before she passed away several months later.

The year also saw me gain Dutch nationality. Both Phillipa and I had mastered the way the country worked in our respective fields. We were pleased with the school system and how Jeremy and Christo were growing up. The language was clearly no longer a problem. As the new millennium dawned, really only one difficulty had remained, more for Phillipa than for me, I must admit. That is, we could vote in the local village elections, but not for the national government. It was time to do something about this. Phillipa had taken the plunge in 2002 and applied for Dutch citizenship. She was pleased that she would not have to give up her Australian nationality to do so. Her application seemed to take quite a long time to process, and then she was told she would indeed have to relinquish her Australian passport. Well, she had researched the matter carefully and replied that there had been a window of some months during with it had been permitted to retain her Australian citizenship, and her application had been submitted during that time. The Dutch immigration people had to admit it was so, and finally she was granted Dutch nationality. Unlike in the US or Australia, there was no ceremony, just a notice from the town hall that she was now a citizen.

At the time I was flat out with LOFAR and other work-related matters, but toward the end of 2004 I also applied to become Dutch. There turned out to be no question of my having to give up my American passport. During the interview at the town hall in Roden, I was told, because my spouse was Dutch, all I would have to do would be to obtain a police report clearing me of any criminal convictions during the previous decade. I duly filled out the required forms, and several weeks later I was called once again to the town hall. This time the story was that all the police records from the relevant period had been lost, so I could not get a police report. My initial reaction was that I would now probably have to wait for a decade to establish my worthiness, before applying again. But the lady behind the counter said she recognized me, having seen me around Roden for many years, so she was sure it would be all right for me to be granted citizenship. So she got the papers signed then and there, and it was done! Phillipa and I were both now Dutch and officially European. We could live and work anywhere in Europe. It felt good.

If the years 2003 to 2005 were in general wonderfully fulfilling, the high point for me personally occurred on 26 April 2005. Minister van der Hoeven came to Groningen formally to inaugurate the new IBM BlueGene computer for LOFAR. At the time, for a short while, it was the fastest, most powerful supercomputer in the world. This impressed a good many people and lots of important people attended. After the ceremony, she asked everyone for their attention, and proceeded to present me with a knighthood from Queen Beatrix, for my contributions to astronomy and multidisciplinary science, innovation and outreach. This came as a total surprise to me, but I later learned that Phillipa, who was present with Jeremy and Christo, had known about it for weeks!

All this seemed too good to last…and it didn't.

In early 2006, NWO not only had a new Governing Board with a new chairman (a successor to van Duinen), but also a new Managing Director of its central administration. Initially, he came across as a result-oriented individual with whom we could do business. He noticed, however, that our budget for 2004 consisted of an annual base grant from NWO of M€ 6.7, and a project and contract budget of M€ 27.5. We were proud of this ratio, and the foreign evaluation panel of the period complimented us as well on our success in acquiring external funding. But it set off alarm bells to him, presumably because if things went wrong, ASTRON would not be able to cover the losses. In that he was right, my view being that NWO existed to ensure that the best science could be done, and we were acknowledged in all our external reviews as doing just that. The problems we had were manageable and we were managing them.

Then, as part of his putting his own stamp on the NWO administration, he implemented a regime of provisioning for asset depreciation. Not of telescopes and buildings, thank goodness, but of furniture and lab equipment. This was a long overdue step toward healthy financial management. But of course, to pay for it he removed funds from our Institute's budget. He also threatened to charge us interest on the ICES/KIS-3 loan, and even to resurrect the deficit caused by the initial cuts to our budget from the late 1990s, which we had explicitly been told we would not have to repay. Now we had a number of problems that we probably couldn't manage.

Finally, although it was policy for government funded research institutions to build closer ties to industry and profile themselves widely in the general public, he decided ASTRON should focus only on astronomy and stop working with commercial companies and supporting all the geophysics, agriculture and IT research that was LOFAR. He clearly thought our ongoing inter-

national ambitions, such as for involvement in SKA and a proposal to build on our successful hosting of JIVE to also host a putative International Centre for Radio Astronomy, were over-reach. He found our setting up of foundations for JIVE and LOFAR, and especially the limited partnership for LOFAR, as complicating structures that would not allow NWO to manage ASTRON adequately. When I gently pointed out to him that all these ambitions and organizational structures had been discussed and formally approved by both the ASTRON and NWO governing boards, as required, he changed the subject.

Now he started looking in detail at the LOFAR budget, with its matching requirements. Although the Ministry of Education, Culture and Science, our administering agency for ICES/KIS-3, was satisfied that things were in order and that we had time and prospects for achieving all the matching required, he decided the inherent risks for NWO were too great. Although NWO as parent organization was at all times intimately involved in our financial management, I as ASTRON Director together with the ASTRON Board were accused of having mismanaged the LOFAR finances, presumably because not all the matching funds had been identified before the project started construction. He called us three times to The Hague to harangue us in front of the NWO Board. Unfortunately, it was a weak Board, and even seemed intimidated by its own Managing Director. It became evident that the latter wanted to create a financial crisis for his own purposes. What those purposes were was never stated explicitly, but I would hazard a guess that he felt he needed to be able to control the finances of NWO's institutes if he was to improve NWO's own financial situation. Well, it was true that Eugène and I had set up our program via contracts, external grants and independent operating foundations, so that *ad hoc* budget cuts by NWO could not readily be com-

pensated at ASTRON, at least not on the short term. This was hardly done with malice aforethought: We were not allowed by statute to go fully commercial and build up a large financial buffer, so our only alternative to what we did was to give up our scientific ambitions, and neither my Board nor I were willing to do that. After all, Reinder van Duinen had said we could do anything, so long as it was legal.

NWO began talking seriously about converting ASTRON's mission to one focusing on academic research, with no more than 10% or so of its budget to be earned externally of NWO and the science system. Our highly successful program would have to be partially dismantled, talented engineers let go, and more academic astronomers hired. I was not interested in this scenario and besides, I had served three terms, 15 years, as ASTRON Director, which was enough. In truth, I was tired and did not look forward to another term.

Eugène could see which way the wind was blowing and also didn't like it. By early 2006, he had decided to leave, as did Joris van Enst. A year later Ria also left. The ASTRON Board applied pressure on me to stay until a successor was found, and I did.

Mike Garrett took over on 1 February, 2007. He is a radio astronomer with specialization in VLBI and he had been working at JIVE. He was confronted with implementing NWO's policy of scaling ASTRON back and redirecting its program.

Shortly after his appointment, the ASTRON Board of Governors decided to resign *en masse*. Its chairman, Thijs van der Hulst, a professor at the Groningen University, had stood by the ambitions of the organization, and by me personally I must say, during an exceedingly difficult time. He had an international reputation for his research on hydrogen in galaxies, much of which used data from the Westerbork telescope, but he was not personally involved in LOFAR or the ASTRON

technical program. He had no personal reason not to acquiesce to the enormous pressure from NWO to have the Board dismantle the program. To his everlasting credit, he resisted. Ultimately, however, the Board must have felt that its relations with the mother organization had become irreconcilable, and had no option but to resign.

A new Board was quickly appointed, consisting almost entirely of non-astronomers. Reassuringly, the Ministry of Science took note of these developments and negotiated with NWO to increase ASTRON's base budget, expressly to guarantee that LOFAR could be properly exploited as it went into full operation. If the program of technical innovation was to be curtailed, at least the scientific output of LOFAR would be realized.

As of 2014, the telescope was operating very productively, and the budget of the organization is mostly derived from within academic science funding lines, including especially through a new program of generous European Union grants. With such research grants, the funding goes largely on students and postdocs, and the financial risks are minimal indeed.

As Eugène departed, Michiel van Haarlem took over as Director of the LOFAR Foundation. Jan Reitsma and his team, in a truly heroic effort, finished the construction of LOFAR, and Queen Beatrix formally set the telescope in operation on 12 June 2010. I am pleased to report that the final expenditure for the telescope infrastructure was M€ 108, near enough to the original estimate of M€ 113, although some additional de-scoping had turned out to be necessary.

International interest in LOFAR continued to increase. By 2014, there were a total of ten antenna fields outside of the Netherlands, all connected to the data processing center in Groningen by the fiber optic cables of the European academic internet. Three more are under construction and shortly, the telescope will extend 1500 km east-west and 1000 km north-south. Now, the

larger the telescope the sharper the images of the sky it makes, and LOFAR is already producing images with unprecedented detail. Technically, it has already met all its specified goals and represents the state-of-the-art in radio telescopes. I am very proud of the part I played in its innovative design and in getting it financed.

As to the other parts of the ASTRON work program, I am also proud that the optical group was able during my tenure to build very advanced instrumentation for the ESO Very Large Telescope and for the NASA-ESA James Webb Space Telescope (the successor to the Hubble Space Telescope, scheduled to be launched in 2018). NWO has now formally removed the optical program to the universities, but the engineering team still works at ASTRON's Dwingeloo lab. JIVE and VLBI are still going strong and have recently been made a formal European organization, which is still being hosted at ASTRON.

The remaining programmatic effort was the Square Kilometer Array. The technology development program has been a spectacular success, with major advances in noise and signal processing performance. Unfortunately, the international SKA leadership continues to see the project as global in nature, with concomitant organizational difficulties. Furthermore, its management is fraught with contradictions and unrealistic goals. The site is now to be split between Western Australia and South Africa; the Americans have insisted that the frequency range should extend to many Giga-Hertz, driving the cost to well over two billion dollars; and there is still no recognized international organization willing to take the project on.

I fear the SKA may not be built in my lifetime, or will go forward only in very reduced form. Ah, well. It has driven some wonderful technology development, including much that found a home in LOFAR, and by that measure it has helped to rejuvenate radio astronomy as

a research field. Indeed, a member of a recent international evaluation panel commented that ASTRON had 're-invented radio astronomy' – an exaggeration perhaps, but gratifying to hear none the less.

I firmly believe ex-directors should leave when they step down. At the end of 2006, I felt my obligation was to depart. I felt exhausted, my hair had gone grey and I was not interested in another high stress job. Phillipa had tenure at the Groningen University and was enjoying her work and colleagues. Jeremy had finished with university and taken a job at a start-up company in Delft, Fox-IT, which was doing well. Christo had graduated and was in Thailand for a year, but was expected back shortly. All things considered, early retirement in the Netherlands seemed an excellent option.

Phillipa thought we should in any case have a *pied-à-terre* in Delft, so whenever we wanted to, we could be near Jeremy, Christo and their partners. To travel to Delft from Roden took us almost three hours and made a one-day trip uncomfortably long. She asked Jeremy to look out for something. At first he hesitated, then told us the flat next door to his was for sale! As we made plans to retire, we bought the flat at 53 Isaäk Hoornbeekstraat.

But then, as my situation became widely known, I began receiving feelers about my potential interest in various job vacancies. I started to wonder whether I might take on an interesting and not too taxing position somewhere.

In the end, I seriously considered two positions. One was in South Africa at the University of Western Cape, in Cape Town. I would be the only astronomer on the faculty, and the South African astronomers clearly hoped I would take the job. Since Christo and I had spent three months in Cape Town in 1991, I felt a fondness for the country. I had followed the political situation closely as apartheid wound down, and I imagined I

could help in some small way in the transition to a normal society. My contacts among the South African astronomical community were good. I had visited with Phillipa for an international SKA meeting in 2004, and I had sat on an international panel evaluating South African astronomy. So I felt I knew the country and its astronomical community fairly well. I became keen to visit, to see whether Phillipa and I could start a new phase of our lives in Cape Town.

The other position was at Mt. Stromlo in Australia, where I had done my doctorate. Its Director, Penny Sackett, had just stepped down and they needed a new Director. I was invited to visit for an interview in early May with the Vice Chancellor of the Australian National University. Phillipa had been wondering whether we might wish ultimately to retire in Australia, so we decided to travel first to Cape Town, and then on to Canberra, before deciding what to do.

In the event, I found I was very interested in the South African position. It would involve mostly teaching and using other people's facilities, and would be a good transition to retirement. The spectacular beauty of the country again impressed me. The salary was good and I felt I could live with the chaotic organization of the university. Regarding a position for Phillipa, they said they would see what they could do, but couldn't promise anything. Initially, Phillipa looked into working for an NGO in the townships. But then, she got a lift with a secretary from the university, who gave her an earful of the widespread, sometimes unavoidable and occasionally violent crime in the country. She became afraid and let me know she would not be returning to South Africa.

In Australia, I gave a colloquium on LOFAR at Mt. Stromlo and talked to the staff, many of whom I knew from my time there in the early 1970s. Subsequently, the Vice Chancellor was most welcoming. He had initially thought I would not be seriously interested

in the job, fearing I would use an offer as leverage to gain promotion back in the Netherlands. I had assured him I was well acquainted with Mt. Stromlo and was definitely interested. I had only two requirements: that the salary be reasonable and that Phillipa should also be given a job. To my surprise, he acquiesced to both, finding her fully qualified for a position as lecturer in Developmental Psychology, which of course she very much was. Both jobs were for five years, after which time we would be 65 and could retire.

She and I decided then and there to move back to Canberra, possibly to stay on into retirement.

Historical remarks

By the time we moved to the Netherlands in 1983, the Treaty of Rome had been in force for a quarter century. But it was the Schengen Treaty of 1985 that had the greatest effect on our daily lives. All of a sudden, there were no more border controls to our neighboring countries. Schengen made people actually feel more European. This feeling was given legal force with the 1993 Maastricht Treaty, when the European Community officially became the European Union and citizens of its countries formally became European citizens, with the right to travel, live and work in any EU country. Europe was becoming an easy as well as interesting place to live. Conversion of our guilders to euros in 2002 completed the transformation, at least as far as Phillipa and I were concerned. Shortly thereafter we took on Dutch/European citizenship.

During the 1990s, economists proclaimed that the USA was improving its economic performance dramatically, while Europe was mired in low productivity growth and stubbornly high rates of unemployment. The claim led to calls for reform in Europe. Flexible labor markets, lower taxation, and less regulation generally, were the proposed remedies.

A more nuanced picture began to emerge in the early 2000s. When country specific policies were analyzed, and especially when the level of income inequality was included as a factor, the stark difference in performance either disappeared or could be understood as possibly even desirable. Labor productivity per hour worked was actually similar in the USA and Europe; the perceived difference derived mainly from Americans working more hours on average. Europeans apparently prize their free time more highly than do Americans.

Now, there is no question that a tradeoff exists between economic efficiency – *i.e.* minimal restrictions on economic activity – and economic and social equality. Generous welfare systems, high and progressive taxation, and strong trade unions are indeed restraints on economic growth. At the same time, they promote income and wealth equality. American society accepts a high level of income inequality. Continental Europeans evidently make the choice for a more equitable society.

Several countries in Europe – Denmark, Norway, Sweden, the Netherlands – have instituted policies that to a significant degree ameliorate the effects of those restraints. Measured in conventional terms, these countries have been able to equal the economic performance of the USA in recent years, while maintaining control of income inequality.

Is the very significant income inequality currently seen in the USA necessarily a bad thing? Recent studies of US society show it leads to inequality of education and of health, and therefore of opportunity, and ultimately to a reduction in social mobility. History tells us that if inequality becomes too large and social mobility too limited, social unrest is likely to follow. How this will play out in the USA remains to be seen.

Chapter 11
Back down under

He was a good director. My husband began to want to go to work again.

– Wife of a Stromlo employee

My initial impression on returning to Canberra was that Australia had become Americanized. No longer were tailored short pants and knee socks part of the dress code in the public service. Materialism had become rampant, and individualism had the upper hand over 'mateship'. The American spelling of words had gained currency and American-like shows dominated television. McDonalds was everywhere.

At least the pubs were open at sensible hours now, and had not taken on the sleazy character of American bars. There were now many immigrants of non-European extraction, and the restaurants they ran were both many and the food they served, oh, so much better. The coffee was good and available pretty much everywhere. Most vestiges of British colonial culture had been erased. In many ways, it was a different country to the one I had left all those years ago.

I took up the directorship at Mt. Stromlo on 28 September 2007. The staff welcomed me warmly and I quickly felt at home. Phillipa had stayed behind in the Netherlands to finish up at her work and to sell the house on Floralaan. I was able to rent a house at Mt. Stromlo on the Observatory grounds, while I waited on her arrival.

The defining event at the Observatory during our long absence had been the devastating – the word was used by everyone whether on TV, in the newspapers, or in general conversation – Canberra bushfires of January 2003. These had killed four Canberra residents and destroyed or damaged over 500 homes. Mt. Stromlo lost most of the Observatory's buildings and telescopes, all in fact except some offices and houses on the lee side of the mountain. When I arrived, one first entered the Observatory grounds only to be confronted by the ruins of the historic Director's house. None of the telescopes had been replaced or renovated, although those domes that had not actually melted had been repainted on the outside. The administration building dating from 1927 had been reconstructed according to the original plans, and the technical workshop had been replaced by more or less modern engineering facilities.

Upon discrete inquiry, I discovered that the University had severely under-insured its assets, and that there would be no possibility of resurrecting the remaining ruins, at least not on the short term. Indeed, there seemed to be no interest at all within the administration to do anything more about the facilities. My admiration for my predecessor as Director, Penny Sackett, grew as I saw what she had accomplished in the face of University indifference.

Even so, as is often the case with organizations in difficulty, it proved hard to spend the available money. As I learned about the budgetary situation, I found there was funding enough left over from the available

re-build funds to fix an over-spend in the operating budget. But the available funds were earmarked for investment in a new library. The staff did not want a new library, because all the interesting research literature these days is quickly put on-line, generally even before it is formally published. But the University was adamant that we could not spend investment funds to repair an operational problem. Thankfully, however, they didn't seem much worried about the deficit; I decided not to worry either. At least I would not make the problem significantly worse during my tenure.

While talking with staff, it became evident that two general issues would define my period as Director.

First, we needed to strengthen the academic staff. We would want to replace the high-profile, mid-career academics who had left following the fires. The remaining staff had very high scientific reputations, but were aging. Additional experienced researchers would be essential to build for the future. We would also want to recruit a number of promising, early career researchers on temporary contracts.

This initiative would be aimed at re-branding the Observatory – from the-one-that-burned-down, to one doing cutting edge research, hiring the best young researchers and attracting frontline visiting astronomers from overseas. The tactic was to undertake a campaign of global recruitment. I would approach and deal with likely mid-career candidates personally. For the early career researchers, we would offer a five year contract without any responsibilities except one's own research, together with a modest budget to support that research, for example for travel and computing. Both of these actions would ultimately prove successful.

Second, with only the small research telescopes remaining, at the dark sky site at Siding Spring NSW, some 700km to the north of Canberra, our students and staff would mainly have to use public telescopes for their

research. The largest and best facilities would be overseas, on Hawaii and in Chile. To gain access to these, it would behoove us to be able to contribute to them, either with cash or by building instrumentation their users might want. I was impressed at the technical competence of some of the academic and engineering staff, and decided we had to build up our capability in instrumentation. I had done this in Dwingeloo, and I somewhat naively imagined I could do it again here without great effort.

The Australian astronomical community was at some level involved in the SKA, and the CSIRO was busy designing its own prototype telescope using small dish antennas. Together with the university community, they had also begun to develop a low frequency radio array in Western Australia, a scaled down and descoped version of LOFAR, if you will. These were technologies I knew a lot about, and it would seem logical to have Stromlo become involved. Alas, the research staff counted only one radio astronomer, and I quickly learned that the Australian radio community did not want my involvement, presumably because of hard feelings left over from the LOFAR consortium breakup. Ah, well. We had very impressive talent in optical technologies and a very nice optical laboratory.

Furthermore, Penny Sackett had convinced the ANU to join an American project to build a mammoth new telescope, the Giant Magellan Telescope, to be sited at an excellent location in Chile. This project involved colleagues I knew well in Pasadena, Tucson, and elsewhere in the States. It would, therefore, be appropriate to focus at least initially on becoming involved in the construction of the telescope and in developing instrumentation for the GMT. The only problem with GMT participation was that we needed to find M$ 65 to become a 10% partner. That is, ANU had joined the project, but had not yet committed significant funding to

become a serious player. This challenge would occupy my daily thoughts during the first two years of my directorship.

Phillipa arrived in January 2008, to start work in February as a lecturer in Developmental Psychology at the ANU. But our first task was to find a house. We spent some weeks looking all around the city. The country was in the throes of a drought that had already lasted a decade. It made for a most unattractive landscape generally. In Canberra, gardens were parched and brown, making it hard to get enthusiastic about most houses. We also found that houses older than about 15 years were poorly designed. Insulation generally was poor, and some even sported a novel concept of central heating, namely a single gas heater located (centrally!) in the entrance hall. Newer houses were typically far from the university, and essentially all had gardens much damaged by the drought.

We hemmed and hawed, but finally decided we didn't need a house after all. We started looking for an apartment close to the main university campus near the center of town. As luck would have it, we found the perfect one: a three-bedroom, three-bathroom unit on the fifth floor of a brand new block of flats. The workmanship was spotty, but the design was just right, and the location put it within easy walking distance of Phillipa's office at ANU. It turned out to be the first building of what would become Canberra's premier precinct for hip, young professionals. The building won numerous architectural awards, and additional blocks of flats were to be built nearby. Evidently, the city government had decided to start allowing high-density residences near the city center. We could walk not only to the University, but also to shopping, theater, cinema, and various parks. We felt we had arrived.

As Phillipa started work, she found the faculty at the School of Psychology less than collegial. Cooperation

in research seemed uncommon, competition setting the tone. Most of the students turned out to be hard workers and well prepared, however, and as the only developmental psychologist on the staff, she could attract enough graduate students to start up some interesting research. On the other hand, she was surprised to learn that she was expected to fail essentially none of the undergraduates in her lecture courses, even the ones who could scarcely write in English and could not think analytically. The foreign students, especially, had paid large fees, and should therefore be guaranteed a passing grade. This policy took some getting used to.

She made contact with colleagues from her period forty years before in the Public Service. Many had retired, and some had moved away. But those still in Canberra were most welcoming and enjoyable to be with, full of humor and an enthusiasm for life in general that her university colleagues lacked. We began getting together with some of them for morning coffee once a week and with others for lunch once a month. Together with regular short trips to visit sister Helen and her family in Melbourne, Phillipa quickly felt very happy to be back home in Australia.

A particularly bright spot for her came with her appointment to an Expert Working Group of the Prime Minister's Science and Engineering Innovation Council. The Group's charge was to advise the government on the "state of the art understanding of how people acquire knowledge throughout life," and suggest "options that could have a positive transformational impact on the acquisition of knowledge, across the full spectrum of socio-economic environments."

It was a heady time for her, and in December 2009, when they presented their final report to the PM, Kevin Rudd, he called it "stunningly relevant". Now, Rudd was an intellectual of high caliber, which is unusual for a politician, so there was even good hope that

the report might lead to government action. Alas, within 6 months Rudd had been deposed, and the report languished, as most reports sponsored by government do. In any case, I was immensely proud of Phillipa, for it was potentially a most important report for which she worked very hard, and a respected Prime Minister was enthusiastic about the result.

Unlike in Psychology, collegiality was the rule at Mt. Stromlo, and I enjoyed my dealings with staff there. I did find I needed to remove several underperforming technical staff, and this was surprisingly easy compared to what it had been in the Netherlands. A new head of engineering was hired to bring a more professional approach to technical project management, but this was accepted without difficulty by staff, as were tentative steps to begin cooperation with local industry.

Various repairs to the new engineering facilities, built since the fires, were found to be required. Poor specifications originally and shoddy workmanship during construction were the cause. As at most universities, such matters were handled centrally at ANU, and the repair work we had in mind would require intimate cooperation with the university administration and central technical services. I was in for a shock.

It quickly became apparent that the central services were dysfunctional. The several divisions were heavily 'silo-ed' and did not communicate with each other at all. The technical services were staffed with elderly gentlemen who did not have either the knowledge or the inclination to deal with our problems. I asked our financial manager to monitor carefully our expenditures, including internally within the University. He discovered numerous incorrect bookings by the technical services, some likely to be simple mistakes, others smelling of minor corruption. When I reported this to the appropriate administrator, his solution was to deny us further access to the relevant accounts.

At the time, as Director of the Research School of Astronomy and Astrophysics, I reported directly to the Vice Chancellor, Ian Chubb (the CEO of the university, if you will), and met with him monthly. He acknowledged that there were serious problems and assured me he was busy with a major restructuring of the University that should help greatly.

The Vice Chancellor was well disposed to our program, most likely because of Penny Sackett's management following the fires. He had agreed to ANU joining the GMT project as our focus for the future. It was the kind of internationally visible project that the ANU should be undertaking, was his view. The only question was how to come up with M$ 65.

Luckily for us, the 2008 Global Financial Crisis occurred at this time. The Australian government decided to address the situation by stimulating the economy, and to do so by investing in infrastructure. Unlike in the Netherlands, the concept of the 'knowledge infrastructure' did not exist in the Australian context. Nevertheless, part of the stimulus program was to finance new buildings and laboratories at universities. Two boundary conditions were applied: (i) any proposed construction should be 'shovel ready' – that is, able to spend money effectively and right away, and (ii) each university could only propose two projects for consideration. I suggested to the Vice Chancellor that we might propose funding for the GMT, and to my very great surprise, he agreed. Evidently, the ANU had no other shovel ready projects.

A first expression-of-interest failed to get up, but a second attempt was chosen for full submission. In March 2009, we submitted *Giant Magellan Telescope: Laboratory to the Stars*, a 48-page proposal. We proposed to spend M$ 23.4 on repairing, upgrading and extending the engineering laboratory on Mt. Stromlo, and M$ 65 for a 10% share in the GMT. I found the proposal preparation almost beyond belief, after having done the

600-odd page LOFAR proposal to the Dutch government. Evidently, the machinery of the Australian government was unable to evaluate the proposals in great detail, much to our advantage.

I went to all the other Australian universities with astronomy departments, but none would join us on the proposal, and several complained to government that it was inappropriate for the ANU to make this proposal. Even so, and again to my great surprise, we were selected for funding. Evidently, it was the only proposal with a high-profile, international component, and one of the few that could spend money right away.

I can't prove it, but I also think it was the personal involvement of the Vice Chancellor that carried the day – he was very highly thought of by senior figures in the government. Indeed, he later became Chief Scientist of Australia and the government's primary advisor on matters scientific.

Of course, now that finance was available, all the other universities discovered they also wanted to have access to the GMT, and we had to agree to split our 10%, with 5% access for all Australian astronomers, and 5% reserved for ANU astronomers.

Next we had to specify in detail the nature of the new engineering facilities. We thought about the likely contracts for instruments and telescope sub-systems from the GMT project, and decided we could and should compete for several major contracts. But at the same time, it became clear that the volume of work would almost certainly be insufficient on the long term to support both the engineering staff and facilities required for the GMT involvement; we would need to identify additional sources of income.

A tour of companies and university groups around the country led us to conclude that the market for space-qualified instrumentation just might provide the needed additional work, as well as make use of very similar en-

gineering capabilities to those required for GMT. Indeed, the project management protocols required for space-qualification would also ensure our GMT instruments would function reliably after delivery. We made certain that our vacuum test chambers, clean room, EMC and vibration qualification units would be appropriate for both GMT and satellite projects. This was a bit of a gamble, because Australia had since the 1960s consistently avoided significant involvement in space research. But it seemed the importance of space for communications and for environmental management would be growing, and we might get in on the ground floor of a new wave of investment and future activity.

We did manage to win a number of GMT contracts: one in the first round of instruments, worth some M$ 25; a telescope sub-system for adaptive optics, to correct for the blurring of starlight as it comes through the Earth's atmosphere; and a software control system study. We thought we might be able to win back over half the M$ 65 investment in the GMT.

All this had to be shepherded through the university bureaucracy, of course. The restructuring promised by the Vice Chancellor was now taking place, but in the event it assumed a particularly pernicious form. Instead of analyzing and optimizing the required processes, a system of colleges, each with its own mid-level bureaucracy was instituted. Henceforth I would report to the Dean of Physical Sciences rather than to the Vice Chancellor, and the Dean had no authority over the central technical services we required. Furthermore, the college administration focused almost exclusively on student admin. College and central administrations were found not to communicate well, and even frequently worked at cross-purposes. It began to take forever to obtain approvals for external contracts. Staff in the central legal office, who were responsible for approving all contracts with outside organizations, had been replaced and the

new lawyers not only had no experience of contracting with commercial and international organizations, but they also seemed afraid to do so. The situation led to endless meetings, unrealistic requirements in contracts, and long delays. The immediate result of the restructuring was constipation, at least as regards anything our technical program needed. Not to put too fine a point on it, I became dismayed and then disgusted.

I thought of trying other ways to generate income, ones that were more in tune with the University culture – a space and astronomy museum on Stromlo overlooking the city, involvement with local high schools, visitor accommodation using the ruins of the heritage Director's Residence, on-line coursework. None of these gained any traction. The University was simply not interested in innovating. I began to suppose I could not think like a good Australian university employee.

One bright spot in the gloom was the EOS-Space Systems Company. This was a small company that for many years had had a satellite laser ranging observatory on Mt. Stromlo. Now they were thinking to move into the monitoring of space debris. They had a 1.8-m telescope with which they used lasers to track bits of debris as small as ten centimeters in size in low Earth orbit. To identify and track smaller objects, they needed adaptive optics, a technology we were developing for GMT use. We began to work together, gaining various grants and supporting each other's programs.

The University had enormous difficulties with this, largely because of the perceived risks of partnering with a commercial company, but we pressed ahead anyway. When the movie *Gravity* came out, graphically demonstrating the need for the management of orbiting debris, our program got a major boost, and all Australian efforts with space junk ended up being coordinated from Mt. Stromlo. I enjoyed working with EOS-Space Systems because when they agreed to do something,

they actually did it, and did so without the endless hassle that characterized the ANU.

The other bright spot was Brian Schmidt. Brian was an American who had done his PhD at Harvard. There, he married an Australian girl, and she wanted to live in Australia. He applied twice to Mt. Stromlo for a post-doctoral fellowship and was rejected twice. But in 1995, on his third attempt, he got lucky and was offered a position, one that gave him a lot of freedom. He used that freedom to work with colleagues in the US, Europe and Chile to study distant exploding stars called supernovae. The team found that these stars could be used to study the expansion of the Universe, and that the expansion was not slowing with time as everyone had expected, but was actually accelerating. There was, and still is, no known physics that can explain this. The discovery led to his co-winning of the Nobel Prize in Physics in 2011. Sometimes such recognition goes to people's heads, but Brian remained a thoroughly nice guy, carefully looking after his students and giving his various prize monies away. He was a joy to have on staff as well as giving our reputation an enormous boost.

He was also one of those rare individuals who is spectacularly productive; he not only was a world famous astrophysicist, but he owned a vineyard and produced wine that could be bought in stores and restaurants around Canberra. He provided bottles of his wine as honoraria for colloquium speakers at Mt. Stromlo. Each year in March, he invited his many acquaintances to help him pick the grapes and afterwards enjoy pizzas from his imported, wood-fired pizza oven. He was well known around the region for his pastries as well as his wine, and as I left the Stromlo directorship in 2013, he was moving into truffles.

Despite my frustrations with the University, I enjoyed my time at Mt. Stromlo. The staff were friendly and generally accommodating, and our international

reputation grew during my tenure, both scientifically and technically. My successor, Matthew Colless, is a well-known and respected astronomer, who promises to keep the program running well.

On 7 January 2013, I formally retired as Director and as Professor. I was granted Emeritus status, and as of this writing, I occasionally still attend colloquia and other meetings at Mt. Stromlo. Phillipa retired a month after me, and has continued to work with grad students in Psychology on their research. We have acquired two Bichon Frisé puppies and have settled into a quiet life-style, dividing our time between Canberra and Delft.

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This book is the autobiography of a modern astronomer. It tells of growing up in post-World War II America, of leaving home to study and to pursue a career on several continents. Harvey Butcher writes of his research on the evolution of galaxies and of his struggles with modern life and society.

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